RESIDENTIAL ENERGY AUDIT AND RETROFIT STUDY

Island Lake Tribal Council Communities, Manitoba

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RESIDENTIAL ENERGY AUDIT AND RETROFIT STUDY

Island Lake Tribal Council Communities, Manitoba

Prepared for:

Island Lake Tribal Council Inc.

Prepared by:

IBI Group

With contributions from:

Indian and Northern Affairs Canada
and
Remote Community Demonstration Program
of Energy, Mines and Resources Canada

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ISLAND LAKE TRIBAL COUNCIL INC.
RESIDENTIAL ENERGY AUDITS:
ABSTRACT

This study funded by the Remote Community Demonstration Program of Energy Mines and Resource Canada, resulted in energy audits of 80 bungalows in four communities in the Island Lake Region of East-Central Manitoba.* On-site audits were carried out in December, 1984. The audits included visual inspection and measurement of dimensions, temperatures, relative humidity, wood consumption and flue gas composition (the last three items for selected dwellings only). Retrofit measures dealing with insulating attics and crawl spaces, re-skinning walls, and sealing were costed. Fuel savings were computed using the HOTCAN computer program with estimates of existing fuel wood consumptions used as energy control totals for each house. The results are presented for each house and are combined with a general approach to conserving energy and maintaining the dwelling stock. In addition a suggestion is made to provide adequate fresh air intake to allow moisture -laden stale air to be exhausted.

* The four communities are: Garden Hill, Red Sucker Lake, St. Theresa Point and Wasagamack.

VÉRIFICATIONS ÉNERGÉTIQUES ET RÉNOVATIONS DE MAISONS POUR LES COLLECTIVITÉS DU CONSEIL TRIBAL DE ISLAND LAKE (MANITOBA)

Résumé

Cette étude est le résultat de vérifications énergétiques qui ont été effectuées dans 80 bungalows répartis dans quatre collectivités[1] situées dans la région de Island Lake dans le centre-ouest du Manitoba. Des vérifications sur le terrain ont été exécutées au mois de décembre 1984. Ces vérifications comprenaient une inspection visuelle, des relevés de dimensions, de températures, de l'humidité relative ainsi que la consommation de bois et la composition des gaz de combustion (les trois dernières vérifications ont été effectuées pour les habitations choisies seulement). On a évalué les coûts de rénovation portant sur l'isolation des entre-toits et des vides sanitaires, des murs et du calfeutrage. À l'aide du programme d'ordinateur HOTCAN du Conseil national de recherches du Canada, on a obtenu des données sur les économies de combustible en se basant sur la consommation actuelle totale de combustible-bois pour chaque maison. Les données recueillies pour chaque maison ont été combinées afin d'établir des principes généraux en matière d'économie d'énergie et de rénovation. Enfin, on a suggéré de fournir un apport d'air frais plus grand afin d'évacuer l'air vicié favorisant la moississure.

Cette étude a été préparée pour le Conseil tribal de Island Lake Inc. par le IBI Group avec des subventions d'Énergie, Mines et Ressources Canada dans le cadre du Programme de démonstration dans les collectivités éloignées et des Affaires indiennes et du Nord Canada.

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1 Les collectivités faisant partie du Conseil tribal de Island Lake sont: Garden Hill, Red Sucker Lake, St. Theresa Point et Wasagamack.

SECTION I

OVERVIEW

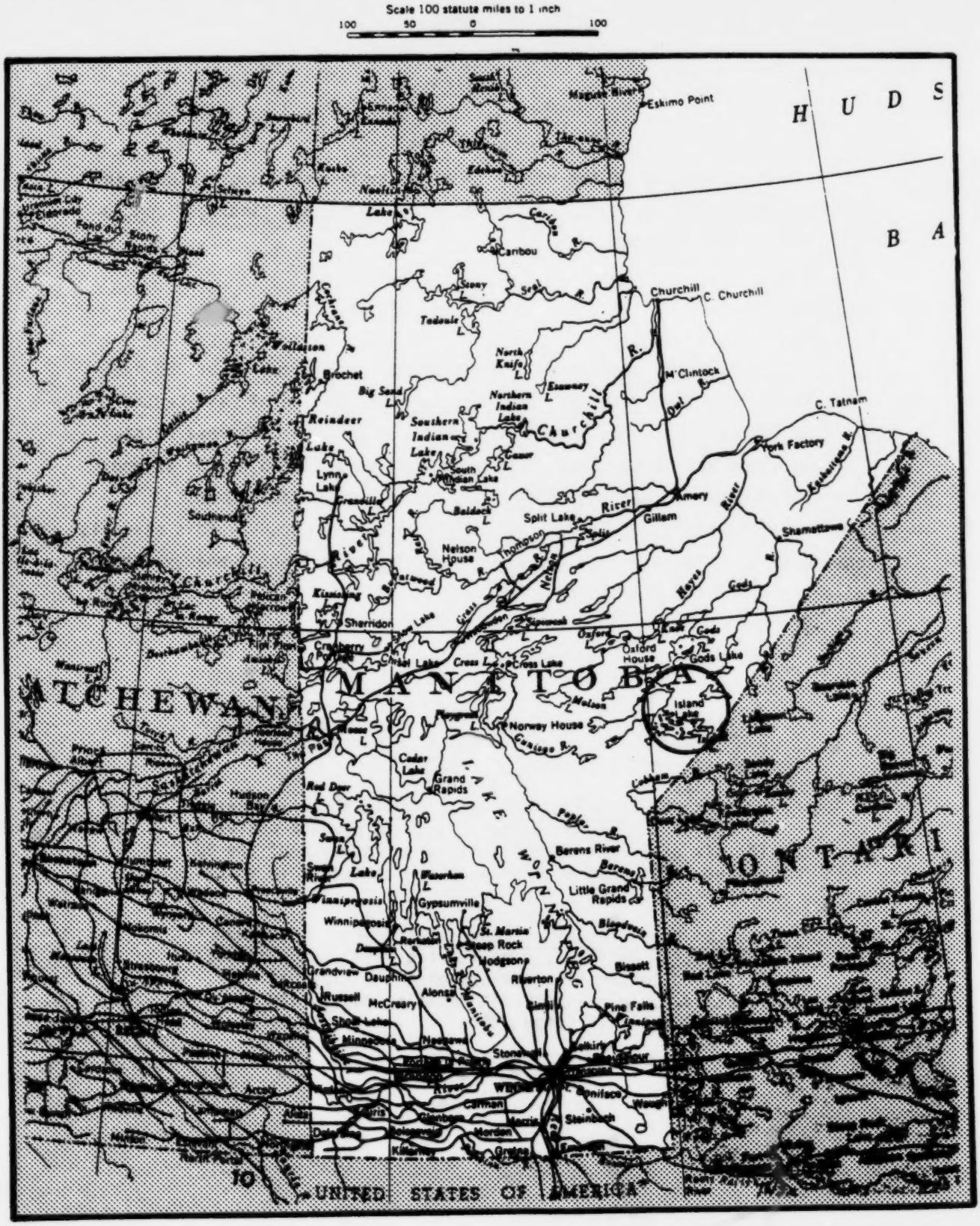
This section of the report provides an overview and includes an introduction providing study objectives, scope, methods, findings, conclusions and recommendations.

INTRODUCTION

This report summarizes the results of energy audits of 80 dwellings located on four reserves in the Island Lake Region of East-Central Manitoba (Exhibit 1). The locations are Garden Hill, St. Theresa Point, Wasagamack and Red Sucker Lake. The work was commissioned by the Island Lake Tribal Council, and was funded as part of the Remote Community Demonstration Program of Energy, Mines and Resources Canada. This study is considered as a first phase, preceeding the demonstration of energy conservation and retrofit techniques.

The report is organized in three sections:

- Section 1: Overview: providing study objectives, approach, details of the methods of investigation and analysis, and a summary of results.
- Section II: Retrofit Analysis: providing an indication of retrofit cost, energy savings, and payback analysis for six different retrofit measures for each of the 80 houses, organized according to the community in which they are located.
- Section III: Technical Appendices: providing further information on flue gas monitoring, air change rates, fuel wood consumption measurements and application, relative humidity, retrofit details, costs, and retrofit analysis computations.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100 50 0 100
MANITOBA
SASKATCHEWAN
ONTARIO
HUDSON BAY
Eskimo Point
Churchill
C. Churchill
Caribou
Tadoule L.
North Knife L.
Essaway L.
M'Clintock R.
C. Tatnam
York Factory
Reindeer Lake
Southern Indian Lake
Northern Indian Lake
Churchill River
Split Lake
Gillam
Nelson House
Nelson River
Sherridon
Oxford House
Gods Lake
Island Lake
Norway House
Cedar Lake
Grand Rapids
Red Deer L.
Berens River
Little Grand Rapids
Gypsumville
Winnipegosis
St. Martin
Steep Rock
Hodgson
Riverton
Grandview
Dauphin
Russell
McCreary
Alonsa
Pine Falls
Stonewall
Winnipeg
Selkirk
Steinbach
Emerson
Gretna
UNITED STATES OF AMERICA

STUDY OBJECTIVES, SCOPE, APPROACH, METHODS

The Remote Community Demonstration Program was initiated to show how various methods to improve energy conservation can be applied in the more remote areas of Canada.

Study Objectives

As outlined in our proposal, the objective of the study is to examine opportunities for residential energy conservation, focusing on:

- Insulation levels in the attic/ceiling, walls, floor;
- Condition of windows;
- Airtightness and controlled ventilation;
- Efficiency of heating equipment.

Opportunities for energy conservation in the above areas had to consider costs as well as effectiveness, and in particular, any life style factors that would affect conservation efforts.

Scope and Approach

The study focused on:

- Reduction in space heating energy used, as opposed to investigating alternative energy sources;
- Energy conservation in single family houses representing a full range of house size, age and condition in the four Reserves served by the Island Lake Tribal Council.
- Consideration of life-style factors that may affect energy conservation measures; and
- Other building science factors such as the possibility for structural deterioration due to soil movement and interstitial condensation.

Above all, the recommendations for conservation had to consider the realities of native life-style, local construction capabilities and availability of materials, and whether or not it would be worthwhile to upgrade dwellings whose structure may need costly repairs.

The study approach relied primarily on visual inspection of the dwellings and was to take place during the late summer or early fall. However, because of the delay in starting the project, on-site inspections coincided with the first half of the heating season. It therefore became possible to make additional observations and do tests under winter conditions.

Methods

The consulting team carried out a variety of activities, some of which involved extensive time spent in the four communities. At the request of the Island Lake Tribal Council, imperial units have been used throughout.

Preliminary Investigation

At the start of work, we collected and reviewed information on the layout of the communities, soil and topography, housing conditions, and construction methods used for the most recently built housing. Arrangements were made for site visits and housing councillors from each of the four reserves were assigned to the project. Their task was to be present at each home during the audit to provide translations to and from Cree. All audited dwellings were selected by the housing councillors on the basis of being representative with respect to size, age and condition.

Site Visits and Observations

On-site work involved visits and observations at two different times:

- o Preliminary visit (during November 1984) to the communities to confirm the various building design features, test the audit procedure (eight houses), confirm investigation and analysis techniques, and learn specifics about life-style.

- o Main audit (during December 1984) of 80 houses (Garden Hill, 30; St. Theresa Point, 28; Wasagamack, 14; Red Sucker Lake, 8) including

  - determination of main building dimensions;
  - number, size, and type of windows;
  - inspection (inside and out) of the building envelope;
  - inspection of attic and crawlspace, where accessible;
  - temperatures at various points in the dwelling;
  - discussions with occupants concerning fuel consumption, and life-style and building problems such as moisture, mould, and movement.

Several other specific types of measurements were made during the main audit. These included flue gas testing; measurement of fuel wood consumption over a 50 hour period, correlated to hourly outdoor temperature readings provided by the local atmospheric environment station; temperature measurements near the stove and near an outside wall in the bedroom located furthest from the stove, air temperature stratification readings, relative humidity measurements, and wood moisture measurements.

Weather conditions for the main audit were ideal for observing performance of the dwellings under winter use. However, temperature and wind conditions made carrying out of the outdoor observations very difficult. During some days, the temperature fell below 0°F. Wind chill factors at times made the effective temperature even lower. However, cooperation of dwelling occupants and careful organization of the visits and translation by the assigned housing councillors, enabled the site visits to proceed successfully.

Analysis

Analysis was carried out in two steps. The first step involved review of field notes recorded during the audit to serve as input to the computer energy simulation procedure, HOTCAN. It was recognized that HOTCAN was developed for dwellings with a homogeneous air temperature in a narrow range centering on about 70°F, and uses conventional degree days as the basis for developing energy demand. Consequently, given the estimated lower steady state temperature in many of the houses and temperature stratification, the HOTCAN projected energy demand may be overstated; heat loss through the floors may be overstated; and heat loss through the ceilings may be understated. However, the HOTCAN energy demand for each house was compared to estimates of actual cord consumption, and the percent split of heat loss into components corresponding to the attic, floor, walls, windows, doors, and air leakage were used to estimate retrofit benefits.

Estimates for R value and/or air leakage for the appropriate component on a before and after retrofit basis were used to estimate the energy unit and dollar savings for each retrofit measure.

All retrofit cost information was provided by staff of the Island Lake Tribal Council. Energy costs were assumed to be $105 per cord, the current price. However, it is recognized that many residents obtain their own wood at no cost from natural growth in the immediate vicinity of the Reservation.

Retrofit Measures

Retrofit measures were developed to deal with the most likely areas of improvement. These areas included:

- Adding insulation to attics;
- Insulating crawl spaces;

- o Re-skinning walls, including insulating the crawlspace perimeter;
- o Replacing existing windows with double or triple glazed lexan units which include a six inch wide insulating shutter for ventilation (addition of storm windows was not considered practical due to their susceptibility to damage).
- o Caulking and weatherstripping.

It was decided that no viable alternative exists for significant reduction in energy consumed by altering the type of stove. An airtight type of stove is available, but is costly and not popular. The airtight stoves currently in use are rarely operated in an airtight manner.

Mechanical controlled ventilation is not practical due to difficulties in repairing electric motors and inexperience with air-to-air heat exchangers. Grilles could be installed between corridors and bedrooms, and bedroom doors could be undercut to promote air circulation.

Comment

Much of the information used in the analysis is approximate and/or estimated. Existing cordage used, interior steady state temperature levels, building envelope condition, retrofit costs, contribution of heat loss by building component are all estimated variables, and can affect retrofit analysis results. Nearly all homeowners were unable to remember the amount of fuel wood used the previous winter. Wide internal temperature swings are permitted in many houses between day time and night time, and between the living areas and bedroom areas. High occupancy levels for large periods of the day may significantly affect energy requirements. Therefore, the results should be considered as approximate and as indicative of the benefits of retrofit, rather than as an accurate forecast of energy savings.

Report

The findings of the study are summarized in three reports. In addition to this report, two earlier reports were submitted:

- o Interim Report; summarizing background information, results of preliminary site visits, and possible retrofit measures;
- o Field Notes and Photographs; provision of raw information collected from the main audit visit.

The contents of the three reports are meant to summarize the project and provide a basis for designing further work.

FINDINGS AND CONCLUSIONS

The dwelling inspections indicate a variety of problems:

- o Low insulation levels;
- o Air leakage;
- o Building movement;
- o Other problems such as lack of adequate crawlspace venting, burning of green wood, and others.

Low Insulation Levels

Insulation levels were low, and in some cases no insulation was applied. In some houses the sheet material supporting the floor insulation had come off and insulation had fallen out. Frost was observed inside the dwellings on exterior walls and ceilings, and on curtains touching some exterior walls. Attic hatches were uninsulated or insulated to low levels. On some newer houses inspection revealed that insulation levels were not as perscribed in the drawings (insulation materials stored on-site may have disappeared before they were incorporated into the building). Indications suggest that the temperature of air at the floor is significantly lower than that at the ceiling, partly due to low or non-existent floor insulation. Windows showed frost and staining at the base and frames, an indication that the windows are not providing enough insulation relative to the interior humidity levels being achieved.

Air Leakage

Extensive indications of air leakage were noted. These include:

- Poorly sealed attic hatches,
- Water leakage between ceiling tiles caused by humid interior air leaking into the attic, vapour condensing and freezing on the underside of the roof sheathing, and subsequent melting,
- Poor or non-existent weatherstripping around doors,
- Shorting of electric wiring in the attic caused by dampness, and leakage around ceiling light fixtures,
- Frost and drafts at electrical outlets in walls,
- Gaps where electrical wiring and television antenna cables penetrate the building envelope,
- Cracked and poorly sealed windows, broken frames,
- Thermopane glazing units leaking at the window base, frosting in this location,
- Floor structures rotting (rare instances),
- Ceiling tiles falling off after becoming damp,
- Disused chimney flues not properly sealed, and in some cases not blocked off,
- Ceiling and floors not properly sealed off after partitions have been moved,
- Lock sets loose or missing on exterior doors,
- Air leakage around wood stove flue where it penetrates the attic.

Building Movement

A few cases of settlement were noted. In some cases, frost heaving caused the centre floor beam to rise in winter, and not fully settle in summer (this may be caused by the colder temperature of the soil supporting the ridge beam as compared to the soil around the perimeter of the house,

supporting the perimeter foundation elements and insulated by a thick blanket of snow).

High Humidity

Relative humidity measurements and calculations were made for 23 dwellings at Garden Hill. Generally, the relative humidity was high, confirming the cause of the staining and frosting on interior surfaces. Given the strong likelihood of gaps and cracks in the interior surface materials, insulation and structural components could be damaged by condensed water vapour in the air leaking from the heated space.

The causes of this humidity include heating water for washing, cooking activities, snow on wood brought into the house for heating, and the occupants themselves.

Other Problems

Other building problems encountered from the brief inspection and/or discussed in varying degrees with residents included:

- Possible presence of carpenter ants in the crawlspace;
- Linoleum floors not holding up to average usage;
- Attics used for storage, resulting in disturbance of insulation and the air/vapour barrier;
- Lack or improper use of crawlspace venting,
- Burning of green wood (45% moisture content, versus 20 or 25% moisture content of air-dried wood).
- Frosting on electrical fuse boxes which are recessed into the exterior wall cavity.

These problems, while not all strictly related to energy use, may be significant with respect to prolonging the life of the dwelling units, thereby making them candidates for retrofit investment.

CONCLUSIONS/RECOMMENDATIONS

The findings of the study suggest that a number of actions may be taken to reduce energy consumption and extend dwelling life. Items 1, 2, and 3 below are high-lights of Exhibit 2, which summarizes the paybacks of the proposed retrofit measures for the 80 houses that were audited.

1. Upgrade Insulation Levels

From the retrofit analysis additional higher levels of insulation would be beneficial:

- Upgrade ceilings to R-40; the retrofit analysis suggests a payback under five years in about 20% of the dwellings and a five to ten year payback in 59% of the dwellings.
- Crawlspace insulation; the retrofit analysis suggests paybacks under five years for about 30% of the dwellings, and paybacks over 15 years in 62% of the dwellings.
- Re-skinning walls and insulating crawlspaces; the analysis indicates paybacks under 10 years for about 30% of the dwellings and paybacks of over 15 years in 60% of the dwellings. These figures represent an averaging for the two re-skinning options presented.

Irrespective of length of paybacks, the dwellings would become much more comfortable after retrofitting the crawlspaces.

Re-skinning of walls generally does not have an economic payback (i.e. under 10 to 15 years). However, for those dwellings where there are conditions causing high humidity, it is likely that condensation is occuring within the wall cavity and structural deterioration may have started. Such cases would have to be varified on a house-by-house basis. Given this problem and the difficulty of maintaining fully-sealed interior wall surfaces, re-skinning from the outside may be justified in that it would prolong the life of some dwellings.

EXHIBIT 2

PERCENTAGE BREAKDOWN OF PAYBACKS
FOR RETROFIT MEASURES

UPGRADING MEASURE	PAYBACK (YEARS)				
	0-2	2-5	5-10	10-15	15+
Add to Ceiling Insulation	4%	16%	59%	16%	5%
Insulate Crawlspace	1%	29%	3%	5%	62%
Re-skin Outside wall	0%	10%	20%	4%	66%
Replace Windows	0%	0%	5%	38%	57%
Caulk and Weatherstrip	56%	28%	11%	1%	4%

2. Replace Windows

The replacement of windows with fixed double glazing lexan units with integral insulating shutter is necessary not only to reduce existing energy use, but to reduce the possibility of further breakage with its attendant heat loss. Double lexan units provide a 10 to 15 year payback in about 38% of the cases, with about 57% of the cases requiring paybacks over 15 years. Triple glazed units have similar paybacks, but are not recommended (except in a few cases) because they are 25% more expensive than similar double glazed units.

3. Caulk and Weatherstrip

This measure is by far the most cost effective. It shows a payback of less than two years in 56% of all the dwellings examined, and shows a payback of two to five years in 28% of the dwellings.

However, because of high levels of interior humidity and occupancy, provisions for air change should be made. This can be done as follows:

- Air intake pipe with intake at a header below the first floor, opening through the floor underneath or beside the stove; and

- Stack vent in a bedroom with the inlet near the floor, passing through the attic space and through the roof - the portion of the vent must be insulated where it passes through the attic.

In this manner, a simple non-mechanical means is available for exhausting moisture-laiden air and providing fresh air without accompanying cold drafts.

4. Use Air-Dried Wood

An important feature of the native life-style is the daily cutting of wood to meet fuel requirements. This inevitably means using green wood (high moisture content) which reduces energy efficiency in terms of the quantity of wood used. If air-dried wood were used, fuel wood requirements would drop by one-third. Using air-dried wood means that wood would have to be stored over one to two heating seasons. However, such wood is considered communal property. This is a disincentive for individuals to cut and store wood in advance.

An alternative would be to designate wood lot areas for cutting for each season. These designated areas would have reserve members cutting wood on a daily basis during the winter and storing it at these locations. Enough wood would be cut and stored in the first year so that the wood would be air dried by the sun over two winters. Daily winter wood cutting would take place, but only for use of future wood in an air-dried form. Reserve residents would collect the wood from communal storage areas by snowmobile on a daily basis, similar to the task now of collecting freshly cut wood. Wood cutting could therefore become a source of employment for those who wish during the winter.

A further employment opportunity would materialize with respect to reforestation of those areas cleared of wood during the summer. Clearly, unless alternative sources of energy are found, the more convenient sources of firewood will be depleted.

An alternative to obtaining drier wood, while still maintaining the daily cutting of trees, is to use a solar air dryer for each house. This could consist of a shed built against the south wall of the dwelling using lexan panels in a wood frame, serving as doors. Racks would be used to enable log storage for two to three weeks to reduce moisture content of the wood. Such a construction would have the added advantage of serving as thermal storage, enabling high daytime temperatures to be achieved against

the south wall of the dwelling and protecting that wall from the low extremes of night time cooling.

5. Train Local Tradesmen

Energy conservation and maintenance of dwellings would be much easier to achieve if each community had a supply of skills that could address problems as they occurred and do preventive maintenance. New dwellings should be used as an opportunity to train local trades, and should incorporate features to eliminate or reduce the deficiencies discovered in the audits. This will clearly require a special training effort which could become the subject of the Phase II of the Remote Communities Demonstration Program in the Island Lake Region.

6. Improve Living Conditions and Maintain Housing Stock

Further actions would include retrofit, new construction, skills training, and a program of promotion and education aimed at energy conservation. The underlying objective of these activities would be:

- Improve the level of comfort in the dwellings;
- Preserve and improve the existing housing stock where possible.

In this manner, the general quality of life can be enhanced, and the communities will become better places to live and raise families.

Sequence of Activities

Our review of conditions suggests the following activities in sequence for effective energy conservation and preservation of dwellings:

1. All crawlspaces should be made accessible (if necessary by cutting a hatch through the floor), cleared of any debris and the ground covered with a polyethylene vapour retarder. This polyethylene sheet should be

weighted down at the edges with sand, gravel, or lumber. The sheet should be punctured in any low areas so that water vapour condensing from the air above can absorbed by the soil.

2. Houses should be sealed and intake pipe and stack vents should be provided where condensation appears to be a problem.

3. Add crawlspace insulation as discussed and shown in Appendix E to conserve energy and to reduce problems of frost heaving.

4. Ensure that clear vent areas, equivalent to 5-6 square feet, are provided for all insulated crawlspaces. These should be closed in winter and opened in summer.

5. Encourage the use of dry wood for fuel .

6. Implement other energy conservation measures as time and budget permit.

SECTION II

ENERGY CONSUMPTION AND RETROFIT ANALYSES

This section presents the retrofit analyses for some of the 80* houses, organized by location:

- Garden Hill (Field Code - G);
- St. Theresa Point (Field Code - ST);
- Wasagamack (Field Code - W);
- Red Sucker Lake (Field Code - R).

For a detailed explanation of the retrofit analyses and related details, see Technical Appendices E, F and G in Section III.

Note that energy savings for each measure are approximate. This is because although the distribution of energy losses through the various building components can be calculated with a fair degree of accuracy, the actual cordage consumed is more difficult to obtain because of factors discussed earlier (including uneven temperature distribution from room to room and from floor to ceiling, variability of fuel moisture content, etc.). See Appendix G in Section III.

The estimated energy use generally agrees with rough estimates of cordage discussed with those householders who could remember. Note that green wood is sometimes mixed with air-dried wood, so that the exact fuel wood requirements may vary significantly.

The measures are listed in a constant format, as opposed to ranking in order of payback. The constant format enables easier comparison among houses and will assist in developing a plan for demonstration retrofit work.

* A retrofit analysis has been done on each of the 80 houses. These analyses, along with field notes and photographs, are on file with both the Island Lake Tribal Council and the Conservation and Renewable Energy Office of EMR in Winnipeg.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . EDWARD LITTLE
Community . . . . . GARDEN HILL
Field Note Code 04
Estimate Of Present Annual Fuel Consumption (In Cords) 14

(1) UPGRADING MEASURE	(2) HEAT LOSS COMPONENT	(3) % OF TOTAL FUEL CONSUMED AT PRESENT	(4) EXISTING R VALUE	(5) NEW R VALUE	(6) FUEL SAVED BY COMPONENT (CORDS PER YEAR)	(7) TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	(8) ANNUAL FUEL SAVINGS (DOLLARS)	(9) COST OF MEASURE (DOLLARS)	(10) PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	17%	12	40	1.7	1.7	$180	$779	4 to 5
INSULATE CRAWL SPACE	Crawl Space Wall	13% (loss through floor)	15	36	1.1	1.1	$120	$2,110	17 to 18
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	16%	12	22	1.0	2.0	$210	$3,590	17 to 18
	Crawl Space Wall	13% (loss through floor)	15	34	1.0				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	16%	12	24	1.1	2.1	$220	$4,020	18 to 19
	Crawl Space Wall	13% (loss through floor)	15	34	1.0				
REPLACE WINDOWS	Windows - conductive loss	5%	2.5	2.8	0.1	1.0	$110	$2,510	22 to 23
			EXISTING AIR CHANGES PER HOUR	NEW AIR CHANGES PER HOUR					
	- air change loss	13%	0.5	0.25	0.9				
CAULK AND WEATHER STRIP	Air Change	34%	1.25	0.5	2.9	2.9	$300	$370	1 to 2

NOTE : 1. Conductive losses through doors not included in column 3
2. Fuel costs in column 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEOWNER: Edward Little

COMMUNITY: Garden Hill

FIELD NOTE CODE: G4

Ensure that insulation is not blocking soffit vents, and that adequate space for ventilation is provided between the top of the insulation and the roof sheathing. It is important that this be checked because dampness was observed in the roof sheathing along the eaves and at the apex of the roof.

Insulate attic hatch, seal and weatherstrip around attic access or move access to the gable end.

Replace loose-fitting sliding pane type window units either with sealed units or tight-fitting sliding pane type units.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . JOHNNY J AND EVA HARPER
Community . . . . . GARDEN HILL
Field Note Code 610
Estimate Of Present Annual Fuel Consumption (In Cords) 9

(1) UPGRADING MEASURE	(2) HEAT LOSS COMPONENT	(3) % OF TOTAL FUEL CONSUMED AT PRESENT	(4) EXISTING R VALUE	(5) NEW R VALUE	(6) FUEL SAVED BY COMPONENT (CORDS PER YEAR)	(7) TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	(8) ANNUAL FUEL SAVINGS (DOLLARS)	(9) COST OF MEASURE (DOLLARS)	(10) PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	17%	12	40	1.1	1.1	$120	$700	5 to 6
INSULATE CRAWL SPACE	Crawl Space Wall	14% (loss through floor)	15	39	0.8	0.8	$80	$1,550	19 to 20
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	12%	20	30	0.4	1.1	$120	$3,390	28 to 29
	Crawl Space Wall	14% (loss through floor)	15	33	0.7				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	12%	20	32	0.4	1.1	$120	$3,810	31 to 32
	Crawl Space Wall	14% (loss through floor)	15	33	0.7				
REPLACE WINDOWS	Windows - conductive loss	6%	2.5	2.8	0.1	0.8	$80	$1,820	22 to 23
			EXISTING AIR CHANGES PER HOUR	NEW AIR CHANGES PER HOUR					
	- air change loss	16%	0.5	0.25	0.7				
CAULK AND WEATHER STRIP	Air Change	31%	1	0.5	1.4	1.4	$150	$330	2 to 3

NOTE : 1. Conductive losses through doors not included in colum 3
2. Fuel costs in colum 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEOWNERS: Eva and Johnny J. Harper

COMMUNITY: Garden Hill

FIELD NOTE CODE: G10

Signs of moisture were found in the attic including wetting of gusset plates at apex of roof. Movement of moisture laden air into attic is evidenced by condensation along attic hatch casement.

Insulate attic hatch, seal and weatherstrip around attic access or move attic access to exterior gable end.

Replace single glazed window unit in bedroom next to storage room.

The humidity level in this house was relatively high compared to other houses studied. By ensuring that lids are kept on all pots used for heating water, this humidity level can be reduced. In addition, less energy will be consumed to heat the water.

This house appears to be on frost susceptible soil. If it is decided to insulate the crawl space, this should be done as described for the crawl space area in the Reskinning Options (3rd and 4th measures on the retrofit analysis chart) and <u>not</u> as shown in the 2nd retrofit measure on the analysis chart.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . ABRAHAM AND MARY MCPHERSON
Community . . . . . GARDEN HILL
Field Note Code 816
Estimate Of Present Annual Fuel Consumption (In Cords) 8

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
UPGRADING MEASURE	HEAT LOSS COMPONENT	% OF TOTAL FUEL CONSUMED AT PRESENT	EXISTING R VALUE	NEW R VALUE	FUEL SAVED BY COMPONENT (CORDS PER YEAR)	TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	ANNUAL FUEL SAVINGS (DOLLARS)	COST OF MEASURE (DOLLARS)	PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	10%	12	40	1.0	1.0	$110	$700	6 to 7
INSULATE CRAWL SPACE	Crawl Space Wall	15% (loss through floor)	15	39	0.7	0.7	$70	$1,550	22 to 23
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	10%	12	22	0.7	1.4	$150	$3,390	22 to 23
	Crawl Space Wall	15% (loss through floor)	15	33	0.7				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	10%	12	24	0.7	1.4	$150	$3,810	25 to 26
	Crawl Space Wall	15% (loss through floor)	15	33	0.7				
REPLACE WINDOWS	Windows - conductive loss	5%	2.8	2.8	0.0	0.6	$60	$1,970	32 to 33
			EXISTING AIR CHANGES PER HOUR	NEW AIR CHANGES PER HOUR					
	- air change loss	14%	0.5	0.25	0.6				
CAULK AND WEATHER STRIP	Air Change	29%	1	0.5	1.2	1.2	$130	$330	2 to 3

NOTE : 1. Conductive losses through doors not included in column 3
2. Fuel costs in column 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEHOWERS: Abraham and Mary McPhurson

COMMUNITY: Garden Hill

FIELD NOTE CODE: G16

Insulate attic hatch, seal and weatherstrip around attic access or move access to gable end.

Broken pane in kitchen window should be replaced.

Porch door should be weatherstripped at door jamb and sweep-type weatherstripping should be applied to the bottom of the door.

Interior panels in the living room and other cold areas of the house should be removed and wall cavity should be checked to see whether insulation was indeed installed when the house was built. If missing insulation is installed, a polyethylene air/vapour barrier should be put in place on the warm side of the insulation and sealed to adjoining sections.

It should be noted that the accompanying retrofit analysis chart shows the R value of the existing windows to be equal to the R value of the proposed new windows. This is because the layer of polyethylene presently covering some of the windows was assumed to be equivalent to an extra layer of glass. The thermal resistance of the present double glazed units without the temporary polyethylene is significantly less than the thermal resistance of the proposed lexan unit.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . WAYNE AND BARBARA HUDSON
Community . . . . . GARDEN HILL
Field Note Code 022
Estimate Of Present Annual Fuel Consumption (In Cords) 11

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
UPGRADING MEASURE	HEAT LOSS COMPONENT	% OF TOTAL FUEL CONSUMED AT PRESENT	EXISTING R VALUE	NEW R VALUE	FUEL SAVED BY COMPONENT (CORDS PER YEAR)	TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	ANNUAL FUEL SAVINGS (DOLLARS)	COST OF MEASURE (DOLLARS)	PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	11%	12	40	0.8	0.8	$80	$560	7 to 8
INSULATE CRAWL SPACE	Crawl Space Wall	46% (loss through floor)	3	21	4.3	4.3	$450	$1,790	3 to 4
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	12%	12	22	0.6	4.9	$510	$3,060	6 to 7
	Crawl Space Wall	46% (loss through floor)	3	19	4.3				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	12%	12	24	0.7	5.0	$530	$3,450	6 to 7
	Crawl Space Wall	46% (loss through floor)	3	19	4.3				
REPLACE WINDOWS	Windows - conductive loss	5%	2.4	2.8	0.1	0.4	$40	$2,020	50 to 51
			EXISTING AIR CHANGES PER HOUR	NEW AIR CHANGES PER HOUR					
	- air change loss	7%	0.4	0.25	0.3				
CAULK AND WEATHER STRIP	Air Change	16%	0.85	0.5	0.7	0.7	$70	$200	4 to 5

NOTE : 1. Conductive losses through doors not included in column 3
2. Fuel costs in column 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEOWNERS: Wayne and Barbara Hudson

COMMUNITY: Garden Hill

FIELD NOTE CODE: G22

Remove articles from on top of attic insulation to prevent compression of insulation and hence loss of insulating value.

Insulate attic hatch, seal and weatherstrip around attic access or move attic access to gable end.

Loose-fitting sliding window units should be replaced in bedrooms on south wall of house.

Wall section around living room window should be checked for presence of insulation. If insulation is missing, then it should be installed with a proper air/vapour barrier placed on the warm side and sealed to adjoining air/vapour barrier on either side.

The presence of a wind break or porch attached to the side door would reduce air leakage when the door is closed and opened.

Significant damage has occurred to the floor system due to rot caused by excessively high humidity levels in the crawl space. Grade beam vents which are at present blocked should be opened immediately to permit ventilation of crawl space. In addition, a polyethylene vapour barrier should be placed on the ground and weighted down with gravel or sand inside the crawl space to prevent upward migration of moisture from the soil. The rotting of floor joists and supporting beams in this house is so severe that a detailed inspection should be undertaken to determine the safety of this floor system. It can be expected that some form of reinforcement of the floor system will be required.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . HARRY HARPER
Community . . . . . GARDEN HILL
Field Note Code 024
Estimate Of Present Annual Fuel Consumption (In Cords) 7

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
UPGRADING MEASURE	HEAT LOSS COMPONENT	% OF TOTAL FUEL CONSUMED AT PRESENT	EXISTING R VALUE	NEW R VALUE	FUEL SAVED BY COMPONENT (CORDS PER YEAR)	TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	ANNUAL FUEL SAVINGS (DOLLARS)	COST OF MEASURE (DOLLARS)	PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	20%	12	40	1.0	1.0	0110	0700	6 to 7
INSULATE CRAWL SPACE	Crawl Space Wall	20% (loss through floor)	12	36	0.9	0.9	090	01,550	17 to 18
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	12%	20	30	0.3	1.1	0120	03,390	28 to 29
	Crawl Space Wall	20% (loss through floor)	12	30	0.8				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	12%	20	32	0.3	1.1	0120	03,810	31 to 32
	Crawl Space Wall	20% (loss through floor)	12	30	0.8				
REPLACE WINDOWS	Windows - conductive loss	5%	2.9	2.8	0.0	0.6	060	01,900	31 to 32
			EXISTING AIR CHANGES PER HOUR	NEW AIR CHANGES PER HOUR					
	- air change loss	16%	0.5	0.25	0.6				
CAULK AND WEATHER STRIP	Air Change	24%	0.75	0.5	0.6	0.6	060	0330	5 to 6

NOTE : 1. Conductive losses through doors not included in column 3
2. Fuel costs in column 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEOWNER: Harry Harper

COMMUNITY: Garden Hill

FIELD NOTE CODE: G24

Condensation on attic hatch around edges is evidence of leakage of moisture laden air into attic. Insulate attic hatch, seal and weatherstrip around attic access or move attic access to gable end.

When ceiling drips on very cold days, homeowner should go up into attic and determine whether condensation is occurring between the ceiling tiles and the air/vapour barrier, or whether the condensation is occurring within the insulation itself as a result of air leakage through the air/vapour barrier. If the former is the case, then the homeowner should check to see whether the insulation has been disturbed and the ceiling is receiving little benefit from the insulation. If the latter is the case, then apply a new air/vapour barrier to underside of the existing ceiling, add new ceiling panels and caulk between; paint ceiling with oil based paint. In either case, lowering the humidity level within the house will reduce the incidence of condensation. This can be achieved by making sure that all containers used to heat water either on the electric or wood stove are provided with lids. This will also reduce the amount of energy required to heat the water.

Missing panes in the double glazed window units of the northeast and southeast bedrooms should be replaced.

The walls of the northeast bedroom should be checked to ensure that insulation has indeed been placed in the wall cavities. This bedroom was found to be significantly colder than the rest of the house. This contributes to the condensation problem in this room.

It should be noted that the accompanying retrofit analysis chart shows the value of the windows to have a slightly higher R value than the R value of the new proposed windows. This is because the layer of polyethylene presently covering the large living room window was assumed to be equivalent to an extra layer of glass. The thermal resistance of the present double glazed units without considering the temporary polyethylene is significantly less than the thermal resistance of the proposed lexan unit.

This house appears to be on frost susceptible soil. If it is decided to insulate the crawl space, this should be done as described for the crawl space area in the Reskinning Options (3rd and 4th measures on the retrofit analysis chart) and <u>not</u> as shown in the 2nd retrofit measure on the analysis chart.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . ABBIE MASON
Community . . . . . ST. THERESA
Field Note Code STI0
Estimate Of Present Annual Fuel Consumption (In Cords) 17

(1) UPGRADING MEASURE	(2) HEAT LOSS COMPONENT	(3) % OF TOTAL FUEL CONSUMED AT PRESENT	(4) EXISTING R VALUE	(5) NEW R VALUE	(6) FUEL SAVED BY COMPONENT (CORDS PER YEAR)	(7) TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	(8) ANNUAL FUEL SAVINGS (DOLLARS)	(9) COST OF MEASURE (DOLLARS)	(10) PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	10%	12	40	1.2	1.2	0130	0620	4 to 5
INSULATE CRAWL SPACE	Crawl Space Wall	39% (loss through floor)	3	22	5.7	5.7	0600	01,070	3 to 4
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	10%	12	22	0.8	6.4	0670	03,190	4 to 5
	Crawl Space Wall	39% (loss through floor)	3	20	5.6				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	10%	12	24	0.9	6.5	0680	03,590	5 to 6
	Crawl Space Wall	39% (loss through floor)	3	20	5.6				
REPLACE WINDOWS	Windows - conductive loss	4%	2.1	2.8	0.2	1.6	0170	01,720	10 to 11
			EXISTING AIR CHANGES PER HOUR	NEW AIR CHANGES PER HOUR					
	- air change loss	12%	0.75	0.25	1.4				
CAULK AND WEATHER STRIP	Air Change	23%	1.5	0.5	2.6	2.6	0270	0300	1 to 2

NOTE : 1. Conductive losses through doors not included in column 3
2. Fuel costs in column 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEOWNER: Aggie Mason

COMMUNITY: St. Theresa

FIELD NOTE CODE: ST10

Provide leather strap as handle in place of missing locksets.

Seal gaps at joint between exterior siding and soffit.

Provide sealed connection for antenna through exterior wall cavity.

Replace broken aluminum slider on west elevation.

Provide exterior storage shed for possessions stored in attic.

Move attic access to exterior gable end, or insulate interior attic hatch, and caulk and seal around it.

Provide soffit vents and baffles at eaves to promote air circulation in attic.

Provide grilles to allow air circulation into farthest bedrooms.

Replace ceiling air/vapour barrier, warped ceiling tiles where necessary. Seal between ceiling tiles and paint with oil-based paint.

Replace existing window which has single glazing.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . MEG FLETT
Community . . . . . ST. THERESA
Field Note Code . . . . . STIS
Estimate Of Present Annual Fuel Consumption (In Cords) 10

(1) UPGRADING MEASURE	(2) HEAT LOSS COMPONENT	(3) % OF TOTAL FUEL CONSUMED AT PRESENT	(4) EXISTING R VALUE	(5) NEW R VALUE	(6) FUEL SAVED BY COMPONENT (CORDS PER YEAR)	(7) TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	(8) ANNUAL FUEL SAVINGS (DOLLARS)	(9) COST OF MEASURE (DOLLARS)	(10) PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	10%	20	48	0.6	0.6	$60	$620	10 to 11
INSULATE CRAWL SPACE	Crawl Space Wall	17% (loss through floor)	12	29	1.0	1.0	$110	$1,070	17 to 18
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	18%	12	22	0.8	1.7	$180	$3,190	17 to 18
	Crawl Space Wall	17% (loss through floor)	12	27	0.9				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	18%	12	24	0.9	1.8	$190	$3,390	18 to 19
	Crawl Space Wall	17% (loss through floor)	12	27	0.9				
REPLACE WINDOWS	Windows - conductive loss	6%	2.7	2.8	0.0	0.7	$70	$2,290	32 to 33
			EXISTING AIR CHANGES PER HOUR	NEW AIR CHANGES PER HOUR					
	- air change loss	13%	0.5	0.25	0.7				
CAULK AND WEATHER STRIP	Air Change	34%	1.25	0.5	2.0	2.0	$210	$300	1 to 2

NOTE : 1. Conductive losses through doors not included in column 3
2. Fuel costs in column 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEOWNER: Neb Flett

COMMUNITY: St. Theresa

FIELD NOTE CODE: ST15

Replace insulation which has fallen from between the floor joists. Reinforce floor joists where necessary.

Seal/repair exterior corners.

Seal penetrations through building envelope for necessary wiring.

Ensure that insulation is not blocking soffit vents and that air circulation is provided for between the insulation and the roof sheathing.

Insulate attic hatch, and seal and weatherstrip around attic access or provide access from gable end.

Ensure gaps around altered partitions are well sealed.

Seal between ceiling tiles and paint ceiling with several coats of oil-based paint. Ensure that interior partitions are sealed off from attic space so that the grilles promoting air circulation into the bedroom spaces are not also providing a way for interior moisture-laden air to escape into the attic.

Provide gaskets for electrical outlets on exterior walls.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . PHILIP MORRIS
Community . . . . . ST. THERESA
Field Note Code $125
Estimate Of Present Annual Fuel Consumption (In Cords) 8

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
UPGRADING MEASURE	HEAT LOSS COMPONENT	% OF TOTAL FUEL CONSUMED AT PRESENT	EXISTING R VALUE	NEW R VALUE	FUEL SAVED BY COMPONENT (CORDS PER YEAR)	TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	ANNUAL FUEL SAVINGS (DOLLARS)	COST OF MEASURE (DOLLARS)	PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	15%	12	40	0.8	0.8	080	0560	7 to 8
INSULATE CRAWL SPACE	Crawl Space Wall	12% (loss through floor)	15	33	0.5	0.5	050	01,790	35 to 36
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	16%	12	22	0.6	1.1	0120	03,660	25 to 26
	Crawl Space Wall	12% (loss through floor)	15	31	0.5				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	16%	12	24	0.6	1.1	0120	03,450	28 to 29
	Crawl Space Wall	12% (loss through floor)	15	31	0.5				
REPLACE WINDOWS	Windows - conductive loss	8%	2	2.8	0.2	1.2	0130	01,900	15 to 16
			EXISTING AIR CHANGES PER HOUR	NEW AIR CHANGES PER HOUR					
	- air change loss	10%	0.75	0.25	1.0				
CAULK AND WEATHER STRIP	Air Change	29%	1.25	0.5	1.4	1.4	0150	0280	1 to 2

NOTE : 1. Conductive losses through doors not included in column 3
2. Fuel costs in column 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEOWNER: Philip Monias

COMMUNITY: St. Theresa

FIELD NOTE CODE: ST25

Provide screens and louvers for holes cut into end gables.

Replace existing windows which have single glazing.

Ensure insulation is not blocking the soffit vents and adequate space for ventilation is provided between the insulation and roof sheathing.

Insulate attic hatch, seal and weatherstrip around attic access, or move attic access to gable end.

Reinforce crawl space floor where necessary and replace damaged floor sections.

Apply air/vapour barrier to underside of existing ceiling, add ceiling panels and caulk between them. Paint ceiling with oil-based paint. (Existing ceiling may be removed and the existing vapour barrier repaired if this is determined to be easier.)

Provide flashing under leaky windows if caulking on the exterior does not eliminate the problem.

Provide foam gaskets for electrical outlets on exterior walls.

Seal around wiring for power supply where it penetrates the building envelope.

This house appears to be on frost susceptible soil. If it is decided to insulate the crawl space, this should be done as described for the crawl space area in the Reskinning Options (3rd and 4th measures on the retrofit analyais chart) and <u>not</u> as shown in the 2nd retrofit measure on the analysis chart.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . JOHN HASKH
Community . . . . . ST. THERESA
Field Note Code ST26
Estimate Of Present Annual Fuel Consumption (In Cords) 10

(1) UPGRADING MEASURE	(2) HEAT LOSS COMPONENT	(3) % OF TOTAL FUEL CONSUMED AT PRESENT	(4) EXISTING R VALUE	(5) NEW R VALUE	(6) FUEL SAVED BY COMPONENT (CORDS PER YEAR)	(7) TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	(8) ANNUAL FUEL SAVINGS (DOLLARS)	(9) COST OF MEASURE (DOLLARS)	(10) PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	5%	35	43	0.1	0.1	$10	$390	38 to 39
INSULATE CRAWL SPACE	Crawl Space Wall	16% (loss through floor)	12	30	1.0	1.0	$110	$1,990	18 to 19
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	16%	12	22	0.7	1.6	$170	$3,390	19 to 20
	Crawl Space Wall	16% (loss through floor)	12	20	0.9				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	16%	12	24	0.8	1.7	$180	$3,810	21 to 22
	Crawl Space Wall	16% (loss through floor)	12	20	0.9				
REPLACE WINDOWS	Windows - conductive loss	5%	2.5	2.8	0.1	1.4	$150	$1,910	12 to 13
	- air change loss	19%	EXISTING AIR CHANGES PER HOUR: 0.75	NEW AIR CHANGES PER HOUR: 0.25	1.3				
CAULK AND WEATHER STRIP	Air Change	38%	1.5	0.5	2.5	2.5	$260	$330	1 to 2

NOTE : 1. Conductive losses through doors not included in column 3
2. Fuel costs in column 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEOWNER: Jobb Mason

COMMUNITY: St. Theresa

FIELD NOTE CODE: ST26

Seal around wiring penetrating the building envelope.

Seal sheathing or repair as necessary at west corner.

Replace window on south elevation which has single glazing.

Insulate attic hatch, seal and weatherstrip around attic access, or move access to gable end.

Ensure soffit vents are not blocked by insulation and adequate space for ventilation is provided between the insulation and the roof sheathing.

Seal around vent pipe where it penetrates the attic.

This house could have a severe problem if the dew point has now shifted to the attic insulation. A polyethylene air/vapour barrier should be applied under the existing ceiling and new ceiling panels, sealed at the joints, should be installed. The ceiling should be painted with oil-based paint.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . JOSEPH HARPER
Community . . . . . WASAGAMACK
Field Note Code . . . . . WIS
Estimate Of Present Annual Fuel Consumption (In Cords) 10

(1) UPGRADING MEASURE	(2) HEAT LOSS COMPONENT	(3) % OF TOTAL FUEL CONSUMED AT PRESENT	(4) EXISTING R VALUE	(5) NEW R VALUE	(6) FUEL SAVED BY COMPONENT (CORDS PER YEAR)	(7) TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	(8) ANNUAL FUEL SAVINGS (DOLLARS)	(9) COST OF MEASURE (DOLLARS)	(10) PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	10%	12	40	1.3	1.3	$140	$700	4 to 5
INSULATE CRAWL SPACE	Crawl Space Wall	41% (loss through floor)	3	21	6.3	6.3	$660	$1,990	3 to 4
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	10%	12	22	0.8	7.0	$740	$3,390	4 to 5
	Crawl Space Wall	41% (loss through floor)	3	19	6.2				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	10%	12	24	0.9	7.1	$750	$3,810	5 to 6
	Crawl Space Wall	41% (loss through floor)	3	19	6.2				
REPLACE WINDOWS	Windows - conductive loss	5%	1.7	2.8	0.4	1.8	$190	$1,900	10 to 11
			EXISTING AIR CHANGES PER HOUR	NEW AIR CHANGES PER HOUR					
	- air change loss	12%	0.75	0.25	1.4				
CAULK AND WEATHER STRIP	Air Change	20%	1.25	0.5	2.2	2.2	$230	$330	1 to 2

NOTE : 1. Conductive losses through doors not included in column 3
2. Fuel costs in column 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEOWNER: Joseph Harper

COMMUNITY: Wasagamack

FIELD NOTE CODE: W15

Replace soffit vents where necessary. Ensure attic insulation is not blocking the soffit vents.

Inspect crawl space; reinforce/repair rotting floor.

Caulk and patch existing openings in the exterior building envelope including around replacement windows.

Seal around wood stove flue pipe where it enters the attic.

Move attic hatch to a gable end, or insulate existing attic hatch, seal and weatherstrip around hatch.

Remove items stored in the attic.

Replace existing window units which have single glazing.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . MARTIN WOOD
Community . . . . . BASKATONG
Field Note Code 016
Estimate Of Present Annual Fuel Consumption (In Cords) 15

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
UPGRADING MEASURE	HEAT LOSS COMPONENT	% OF TOTAL FUEL CONSUMED AT PRESENT	EXISTING R VALUE	NEW R VALUE	FUEL SAVED BY COMPONENT (CORDS PER YEAR)	TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	ANNUAL FUEL SAVINGS (DOLLARS)	COST OF MEASURE (DOLLARS)	PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	7%	21.7	41.7	0.5	0.5	$50	$520	10 to 11
INSULATE CRAWL SPACE	Crawl Space Wall	52% (loss through floor)	3	20	6.6	6.6	$690	$2,100	3 to 4
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	13%	12.75	22.75	0.9	7.4	$780	$3,570	4 to 5
	Crawl Space Wall	52% (loss through floor)	3	10	6.5				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	13%	12.75	24.75	0.9	7.4	$780	$4,000	5 to 6
	Crawl Space Wall	52% (loss through floor)	3	10	6.5				
REPLACE WINDOWS	Windows - conductive loss	5%	2.2	2.8	0.2	0.2	$20	$2,400	120 to121
			EXISTING AIR CHANGES PER HOUR	NEW AIR CHANGES PER HOUR					
	- air change loss	5%	0.25	0.25	0.0				
CAULK AND WEATHER STRIP	Air Change	15%	0.75	0.5	0.8	0.8	$80	$360	4 to 5

NOTE : 1. Conductive losses through doors not included in column 3
2. Fuel costs in column 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEOWNER: Martin Wood

COMMUNITY: Wasagamack

FIELD NOTE CODE: W16

Caulk around wiring penetrations to the building envelope.

Insulate attic hatch, seal and weatherstrip around attic hatch, or move attic hatch to gable end.

Ensure attic insulation is not blocking existing soffit vents.

Replace insulation and air/vapour barrier where occupant shows it is to be missing in the wall.

Provide thermal break on interior at exterior corners and caulk around trim. Seal corners from exterior where the concrete is spalling.

Replace all existing single glazed window units.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . PHILIP HARPER
Community . . . . . WABABIMIKE
Field Note Code 019
Estimate Of Present Annual Fuel Consumption (In Cords) 10

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
UPGRADING MEASURE	HEAT LOSS COMPONENT	% OF TOTAL FUEL CONSUMED AT PRESENT	EXISTING R VALUE	NEW R VALUE	FUEL SAVED BY COMPONENT (CORDS PER YEAR)	TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	ANNUAL FUEL SAVINGS (DOLLARS)	COST OF MEASURE (DOLLARS)	PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	6%	20	44	0.2	0.2	$20	$521	26 to 27
INSULATE CRAWL SPACE	Crawl Space Wall	14% (loss through floor)	13	32	0.8	0.8	$80	$1,870	23 to 24
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	16%	12	22	0.7	1.5	$160	$3,190	19 to 20
	Crawl Space Wall	14% (loss through floor)	13	30	0.8				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	16%	12	24	0.8	1.6	$170	$3,590	21 to 22
	Crawl Space Wall	14% (loss through floor)	13	30	0.8				
REPLACE WINDOWS	Windows - conductive loss	10%	1.3	2.8	0.5	1.7	$180	$1,810	10 to 11
			EXISTING AIR CHANGES PER HOUR	NEW AIR CHANGES PER HOUR					
	- air change loss	18%	0.75	0.25	1.2				
CAULK AND WEATHER STRIP	Air Change	35%	1.5	0.5	2.3	2.3	$240	$300	1 to 2

NOTE : 1. Conductive losses through doors not included in column 3
2. Fuel costs in column 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEOWNER: Philip Harper

COMMUNITY: Wasagamack

FIELD NOTE CODE: W19

Replace missing soffit and soffit vents; ensure attic insulation does not block soffit vents.

Include the replacement of missing trim where needed when caulking and weatherstripping; seal around wood stove flue where it enters the attic; seal around electrical outlets on exterior walls and provide gaskets and covers as needed.

Provide insulated attic hatch, seal and weatherstrip around attic hatch, or provide access from gable end.

Seal holes in exterior sheathing.

Replace existing window units which contain single glazing.

This house appears to be on frost susceptible soil. If it is decided to insulate the crawl space, this should be done as described for the crawl space area in the Reskinning Options (3rd and 4th measures on the retrofit analyais chart) and <u>not</u> as shown in the 2nd retrofit measure on the analysis chart.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . GEORGE HARPER
Community . . . . . RED SUCKER LAKE
Field Note Code B7
Estimate Of Present Annual Fuel Consumption (In Cords) 5

(1) UPGRADING MEASURE	(2) HEAT LOSS COMPONENT	(3) % OF TOTAL FUEL CONSUMED AT PRESENT	(4) EXISTING R VALUE	(5) NEW R VALUE	(6) FUEL SAVED BY COMPONENT (CORDS PER YEAR)	(7) TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	(8) ANNUAL FUEL SAVINGS (DOLLARS)	(9) COST OF MEASURE (DOLLARS)	(10) PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	14%	20	40	0.4	0.4	$40	$426	10 to 11
INSULATE CRAWL SPACE	Crawl Space Wall	14% (loss through floor)	20	41	0.4	0.4	$40	$1,400	35 to 36
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	15%	20	30	0.3	0.6	$60	$3,060	51 to 52
	Crawl Space Wall	14% (loss through floor)	20	36	0.3				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	15%	20	32	0.3	0.6	$60	$3,450	57 to 58
	Crawl Space Wall	14% (loss through floor)	20	36	0.3				
REPLACE WINDOWS	Windows - conductive loss	10%	2.5	2.8	0.1	0.6	$60	$2,060	34 to 35
			EXISTING AIR CHANGES PER HOUR	NEW AIR CHANGES PER HOUR					
	- air change loss	10%	0.5	0.25	0.5				
CAULK AND WEATHER STRIP	Air Change	27%	0.75	0.5	0.5	0.5	$50	$200	5 to 6

NOTE : 1. Conductive losses through doors not included in column 3
2. Fuel costs in column 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEOWNER: George Harper

COMMUNITY: Red Sucker Lake

FIELD NOTE CODE: R7

Although the metal insulated side door appeared to fit quite tightly, the addition of some form of porch or wind break would reduce the amount of cold air that enters the house when the door is opened. This is of particular importance since this door is on the north side of the house. This house is protected to a fairly large extent by the stand of coniferous trees around it.

ISLAND LAKE RESIDENTIAL ENERGY AUDIT

Energy Savings Of Proposed Measures

Name Of Homeowner . . . . . SOLOMON HARPER
Community . . . . . RED SUCKER LAKE
Field Note Code 88
Estimate Of Present Annual Fuel Consumption (In Cords) 11

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
UPGRADING MEASURE	HEAT LOSS COMPONENT	% OF TOTAL FUEL CONSUMED AT PRESENT	EXISTING R VALUE	NEW R VALUE	FUEL SAVED BY COMPONENT (CORDS PER YEAR)	TOTAL FUEL SAVED BY EACH MEASURE (CORDS PER YEAR)	ANNUAL FUEL SAVINGS (DOLLARS)	COST OF MEASURE (DOLLARS)	PAYBACK (YEARS)
ADD TO CEILING INSULATION	Ceiling	10%	20	40	0.6	0.6	$60	$500	8 to 9
INSULATE CRAWL SPACE	Crawl Space Wall	10% (loss through floor)	20	44	0.6	0.6	$60	$1,550	25 to 26
RE-SKIN OUTSIDE WALL - OPTION A (polystyrene)	Wall	16%	12	22	0.8	1.3	$140	$3,390	24 to 25
	Crawl Space Wall	10% (loss through floor)	20	38	0.5				
RE-SKIN OUTSIDE WALL - OPTION B (batts and polystyrene)	Wall	16%	12	24	0.9	1.4	$150	$3,810	25 to 26
	Crawl Space Wall	10% (loss through floor)	20	38	0.5				
REPLACE WINDOWS	Windows - conductive loss	5%	2.7	2.8	0.0	1.4	$150	$2,100	14 to 15
			EXISTING AIR CHANGES PER HOUR	NEW AIR CHANGES PER HOUR					
	- air change loss	19%	0.75	0.25	1.4				
CAULK AND WEATHER STRIP	Air Change	38%	1.5	0.5	2.8	2.8	$290	$330	1 to 2

NOTE : 1. Conductive losses through doors not included in column 3
2. Fuel costs in column 8 are shown to the nearest $10 and are based on a price of $105. per cord

NAME OF HOMEOWNER: Soloman Harper

COMMUNITY: Red Sucker Lake

FIELD NOTE CODE: R8

Replace missing interior ceiling tiles, repair vapour barrier where necessary, seal between the ceiling panels and paint with oil-based paint.

Replace loose fitting pane type single glazed windows with double glazed units.

Seal loose stove pipe connections with furnace cement to eliminate unnecessary removal of room air up chimney stack on stove in kitchen.

Combustible materials should be removed from the vicinity of the auxiliary wood stove at north end of house.

APPENDIX A

FLUE GAS MEASUREMENTS

Flue gas measurements were carried out in two houses using Draeger gas analysis tubes and a high temperature digital thermometer. Each test required about two hours of measurement recording time.

STOVE TEST #1 - "OVAL"

This was done at the home of Abraham and Mary McPherson (G16) and is summarized as follows:

- 19 lbs. dry wood @ 23% moisture content
- 30 lbs. green wood @ 42.5% moisture content
- green and dry wood is often burned together, so test was representative;
- test was done with both stove vents open, the manner in which the stove is normally operated.

STOVE TEST #2 - "HORIZONTAL 45 GALLON DRUM"

This was done at the home of Edward Little (G4) and is summarized as follows:

- 36 lbs. dry wood @ 23% moisture content;
- test done with vent open (broken, wouldn't close, fairly large opening).

METHODS

For both tests the following quantities were measured at short, regular intervals during the test:

- % concentration of carbon dioxide

- % concentration of carbon monoxide
- % concentration of oxygen;
- stack temperature.

This information plus moisture content of wood, weight of wood, and ambient room temperature were used to compute combustion air requirements and operating efficiency using the method described in CSA Draft Standard No. B415, provided by and used with advice from officials of the Canadian Combustion Research Laboratory.

Gas concentration levels were obtained using Draeger tubes connected to a hot air probe inserted in the stove pipes. Stack temperatures were obtained from a digital thermometer.

Although simplified efficiency tests were originally proposed for several other houses, this idea was abandoned in light of time constraints and the reduced of accuracy of that method.

RESULTS

The observations, calculations and results are summarized in Exhibits A-1 and A-2. The oval stove required air at an average volume flow rate of 39 cfm (cubic feet per minute), and operated at 26% efficiency. The horizontal drum stove required air at an average volume flow rate of 60 cfm, and operated at 24% efficiency. In both cases, the efficiency rating indicates the available energy for space heating purposes taking into account energy needed to drive off moisture contained in the wood and energy escaping up the flue.

WOODSTOVE TEST #1 - 'OVAL'

EXHIBIT A-1

MEASURED OR ASSUMED QUANTITIES	SYMBOL	INPUTTED VALUES					
Time From Start Of Burn (In Hours)	t	0.1	0.32	0.65	1.33	2.02	2.52
Wet Weight of Fuel Charge (kg)	WTw	22.3	22.3	22.3	22.3	22.3	22.3
Present Weight of Fuel Charge	WT	20.46329	16.69943	11.76747	4.305827	0.452292	0
Initial Moisture Content Of Fuel Charge	Mo	35	35	35	35	35	35
% Of C In Fuel At Beginning Of Fuel Cycle	Co	48.73	48.73	48.73	48.73	48.73	48.73
% Of H In Fuel At Beginning Of Fuel Cycle	Ho	6.87	6.87	6.87	6.87	6.87	6.87
% Of O In Fuel At Beginning Of Fuel Cycle	OXo	43.9	43.9	43.9	43.9	43.9	43.9
Dry Calorific Value of Wood At Beginning Of Burn Cycle (kJ/kg)	CVo	19910	19910	19910	19910	19910	19910
Moles Of CO2/100 Moles Of Dry Flue Gas	d	7.5	9	8	10.5	6	3
Moles Of CO/100 Moles Of Dry Flue Gas	e	1.5	1	0.5	0.4	0.4	0.5
Moles Of O2/100 Moles Of Dry Flue Gas	g	12.5	12.5	13	9.5	14.8	17
Stack Temperature (In Degrees Kelvin)	Ts	666	866	889	839	511	411
Ambient Temperature (In Degrees Kelvin)	Ta	295	295	295	295	295	295

STOVE PERFORMANCE PARAMETERS		CALCULATED VALUES					
% Of Total Fuel Plus Moisture Mass Consumed	K	8.236331	25.11463	47.23104	80.69135	97.97178	100
Initial Dry Weight Of Fuel Charge	WTdo	14.495	14.495	14.495	14.495	14.495	14.495
Present Dry Weight Of Fuel Charge	WTdn	14.02308	12.47209	9.528012	3.773646	0.407561	0
% Of Dry Fuel Mass Consumed	w	3.255731	13.95590	34.26690	73.96587	97.18826	100
Dry Weight Of Fuel At Beginning Of Interval	WTdb	14.495	14.02308	11.00005	6.650829	2.090603	0.203780
Dry Weight Of Fuel At End Of Interval	WTde	14.02308	11.00005	6.650829	2.090603	0.203780	0
Change In Dry Weight During Interval	dWTd	0.471918	3.023029	4.349222	4.560225	1.886823	0.203780
% Of Original Wood Moisture Content In Burning Fuel (Wet Basis)	R	2.7630	1.5136	0.6938	0.2325	-0.1049	-0.1640
Moisture Content Of Burning Fuel (% Wet Basis)	Mw	96.70362	52.97547	24.28418	8.136766	-3.67116	-5.74
Moisture Content Of Burning Fuel (% Dry Basis)	Md	2933.637	112.6549	32.07280	8.857478	-3.54116	-5.42840
% Of C In The Dry Fuel Burning	CA	30.64792	35.10362	38.69787	55.33628	91.18631	97.63542
% Of H In The Dry Fuel Burning	HY	8.980224	9.134884	8.731781	5.308864	1.690417	1.171335
% Of O In The Dry Fuel Burning	OX	59.87185	55.26148	52.07034	38.85484	6.623263	0.693237
Dry Calorific Value (kJ/kg) Of The Fuel Burning	CV	12779.55	14273.11	16185.33	23104.73	33921.04	35760.35
Fraction Of C Atoms In The Burning Fuel	a	2.553993	2.925302	3.224822	4.611357	7.598859	8.136285
Fraction Of H Atoms In The Burning Fuel	b	8.980224	9.134884	8.731781	5.308864	1.690417	1.171335
Fraction Of O Atoms In The Burning Fuel	c	3.741990	3.453842	3.254396	2.428428	0.413953	0.043327
Moles Of N2/100 Moles Of Dry Flue Gas	h	78.5	77.5	78.5	79.6	78.8	79.5
Moles Of Oxygen Entering/100 Moles Of Dry Flue Gas	u	20.82228	20.55702	20.82228	21.11405	20.90185	21.08753
Moles Of Dry Fuel/100 Moles Of Dry Flue Gas	w	4.095409	4.831309	3.344872	2.219909	0.880121	0.338515
Moles Of CH4/100 Moles Of Dry Flue Gas	k	1.459650	4.133042	2.286622	-0.66320	0.287921	-0.74573
Moles Of H2O/100 Moles Of Dry Flue Gas	j	15.46954	13.80064	10.03010	7.219007	0.168043	1.689733
Kg Of Dry Wood/100 Moles Of Dry Flue Gas	Nk	0.407493	0.480715	0.332814	0.220881	0.087572	0.033682

STOVE PERFORMANCE PARAMETERS (continued)

CALCULATED VALUES (continued)

Moles Of Oxygen Entering/kg Of Dry Fuel Burnt During Interval	nO2e	51.09846	42.76341	62.56416	95.59019	238.6816	626.0710
Moles Of Oxygen Entering During Interval	tnO2e	24.11430	129.2750	272.1054	435.9128	450.3500	127.5812
Moles Of CO2/kg Dry Wood	nCO2	0.060530	0.031970	0.008403	-0.00152	0.000639	-0.00584
Moles Of O2/kg Dry Wood	nO2	30.67535	26.00291	39.06075	43.00958	169.0035	504.7156
Moles Of CO/kg Dry Wood	nCO	3.681042	2.080233	1.502336	1.810929	4.567664	14.84457
Moles Of HC/kg Dry Wood	nHC	3.582024	8.597692	6.870553	-3.00253	3.287823	-22.1403
Moles Of N2/kg Dry Wood	nN2	192.6412	161.2180	235.8668	360.3750	899.8298	2360.287
Moles Of H2O/kg Dry Wood	nH2O	1667.774	91.29515	47.95555	37.60365	-0.04841	47.15094
Heat Loss In Joules/Mole For CO2	lCO2	0.979737	0.841633	0.231378	-0.03790	0.005693	-0.02670
Heat Loss In Joules/Mole For O2	lO2	352.3299	472.6347	740.6672	742.2487	1101.974	1739.693
Heat Loss In Joules/Mole For CO	lCO	1082.463	624.9280	452.4419	542.4468	1321.591	4251.117
Heat Loss In Joules/Mole For N2	lN2	2116.629	2781.263	4242.938	5906.697	5688.942	7990.130
Heat Loss In Joules/Mole For CH4	lCH4	3248.916	7903.265	6326.136	-2754.72	2955.803	-19806.8
Heat Loss In Joules/Mole For H2O	lH2O	98238.87	6078.836	3237.022	2463.703	-2.58039	2349.228
Heat Losses For All Gases	tloss	49570.39	53996.66	65235.89	31467.07	20879.08	-708.486
Energy Input	E. In	6030.905	43148.05	70393.63	105362.8	64003.00	7287.272
Energy Output	E. Out	-43539.4	-10848.6	5157.731	73895.75	43123.91	7995.758

SUMMARY OF ANALYSIS

Total Energy Input (kJ)	296000
Total Energy Output (kJ)	76000
Operating Efficiency	26%
Average Combustion Air Flow (cfm)	39

WOODSTOVE TEST #2 - 'HORIZONTAL 45 GALLON DRUM'

EXHIBIT A-2

MEASURED OR ASSUMED QUANTITIES	SYMBOL	INPUTTED VALUES						
Time Since Start Of Burn (In Hours)	t	0.1	0.25	0.38	0.65	1.05	1.75	2.7
Wet Weight of Fuel Charge (kg)	WTo	16.4	16.4	16.4	16.4	16.4	16.4	16.4
Present Weight of Fuel Charge	WT	15.13749	13.33821	11.87055	9.094463	5.656987	1.581508	0
Initial Moisture Content Of Fuel Charge	Mo	23	23	23	23	23	23	23
% Of C In Fuel At Beginning Of Fuel Cycle	Co	48.73	48.73	48.73	48.73	48.73	48.73	48.73
% Of H In Fuel At Beginning Of Fuel Cycle	Ho	6.87	6.87	6.87	6.87	6.87	6.87	6.87
% Of O In Fuel At Beginning Of Fuel Cycle	OXo	43.9	43.9	43.9	43.9	43.9	43.9	43.9
Dry Calorific Value of Wood At Beginning Of Burn Cycle (kJ/kg)	CVo	19910	19910	19910	19910	19910	19910	19910
Moles Of CO2/100 Moles Of Dry Flue Gas	d	8	10.5	8	4.5	4	2	1.5
Moles Of CO/100 Moles Of Dry Flue Gas	e	0.1	0.3	0.3	0.3	0.35	0.3	0.3
Moles Of O2/100 Moles Of Dry Flue Gas	g	9.5	11.8	14.5	15.8	16.3	20.5	20
Stack Temperature (In Degrees Kelvin)	Ts	852	777	689	550	536	438	378
Ambient Temperature (In Degrees Kelvin)	Ta	295	295	295	295	295	295	295

STOVE PERFORMANCE PARAMETERS		CALCULATED VALUES						
% Of Total Fuel Plus Moisture Mass Consumed	x	7.698216	18.66941	27.61854	44.54595	65.50617	90.35665	100
Initial Dry Weight Of Fuel Charge	WTdo	12.628	12.628	12.628	12.628	12.628	12.628	12.628
Present Dry Weight Of Fuel Charge	WTdn	11.98500	10.92702	9.958642	7.917018	5.098104	1.468116	0
% Of Dry Fuel Mass Consumed	y	5.091815	13.46988	21.13840	37.30584	59.62857	88.37412	100
Dry Weight Of Fuel At Beginning Of Interval	WTdb	12.628	11.456	10.44283	8.937830	6.507561	3.283110	0.734058
Dry Weight Of Fuel At End Of Interval	WTde	11.456	10.44283	8.937830	6.507561	3.283110	0.734058	0
Change In Dry Weight Of Fuel Over Interval	dWTd	1.172	1.013167	1.505002	2.430269	3.224451	2.549052	0.734058
% Of Original Wood Moisture Content In Burning Fuel (Wet Basis)	R	2.8144	1.9129	1.3812	0.7577	0.4075	0.0753	-0.1640
Moisture Content Of Burning Fuel (% Wet Basis)	Mw	64.73075	43.99731	31.76721	17.42797	9.371366	1.731250	-3.772
Moisture Content Of Burning Fuel (% Dry Basis)	Md	183.5331	78.56287	46.55710	21.10639	10.34040	1.761751	-3.63489
% Of C In The Dry Fuel Burning	CA	31.61711	34.95673	36.82238	39.08946	45.09877	74.16688	97.63542
% Of H In The Dry Fuel Burning	HY	9.024764	9.133350	9.096633	8.592983	6.947239	3.204279	1.171335
% Of O In The Dry Fuel Burning	OX	58.85812	55.40990	53.58098	51.81755	47.45398	22.12883	0.693237
Dry Calorific Value (kJ/kg) Of The Fuel Burning	CV	13078.49	14216.63	15020.69	16463.17	19462.34	28955.21	35760.35
Fraction Of C Atoms In The Burning Fuel	a	2.634759	2.913061	3.068532	3.257455	3.758231	6.180573	8.136285
Fraction Of H Atoms In The Burning Fuel	b	9.024764	9.133350	9.096633	8.592983	6.947239	3.204279	1.171335
Fraction Of O Atoms In The Burning Fuel	c	3.678632	3.463119	3.348811	3.238597	2.965874	1.383052	0.043327
Moles Of N2/100 Moles Of Dry Flue Gas	h	82.4	77.4	77.2	79.4	79.35	77.2	78.2
Moles Of Oxygen Entering/100 Moles Of Dry Flue Gas	u	21.85676	20.53050	20.47745	21.06100	21.04774	20.47745	20.74270
Moles Of Dry Fuel/100 Moles Of Dry Flue Gas	w	1.710294	5.386686	4.241993	1.535268	1.077873	0.736703	0.344215
Moles Of CH4/100 Moles Of Dry Flue Gas	k	-3.59378	4.891750	4.716694	0.201068	-0.29910	2.253247	1.000635
Moles Of H2O/100 Moles Of Dry Flue Gas	j	14.90507	14.81574	9.860544	6.194131	4.342327	-3.32619	-1.79967
Kg Of Dry Wood/100 Moles Of Dry Flue Gas	Nk	0.170174	0.535975	0.422078	0.152759	0.107248	0.073301	0.034249

EXHIBIT A-2
(continued)

STOVE PERFORMANCE PARAMETERS (continued)		CALCULATED VALUES (continued)						
Moles Of Oxygen Enterins/kg Of Dry Fuel Burnt Durins Interval	aO2e	128.4375	38.30494	48.51575	137.8706	196.2522	279.3575	605.6363
Moles Of Oxygen Enterins Durins Interval	taO2e	150.5287	38.80932	73.01632	335.0627	632.8059	712.0969	444.5722
Moles Of CO2/kg Dry Wood	aCO2	-0.02387	0.126045	0.064597	0.000600	-0.00047	0.003164	0.002250
Moles Of O2/kg Dry Wood	aO2	55.82511	22.01593	34.35380	103.4307	151.9836	279.6651	583.9511
Moles Of CO/kg Dry Wood	aCO	0.587632	0.559727	0.710768	1.963875	3.263451	4.092660	8.759267
Moles Of HC/kg Dry Wood	aHC	-21.1182	9.126820	11.17492	1.316241	-2.78887	30.73925	29.21610
Moles Of N2/kg Dry Wood	aN2	484.2093	144.4096	182.9044	519.7723	739.8711	1053.177	2283.249
Moles Of H2O/kg Dry Wood	aH2O	189.5507	71.28898	49.22714	52.27420	46.23321	-44.3978	-54.5655
Heat Loss In Joules/Mole For CO2	lCO2	-0.61101	2.738378	1.118428	0.006409	-0.00474	0.018057	0.007229
Heat Loss In Joules/Mole For O2	lO2	988.0735	333.8834	420.5127	801.3931	1110.332	1193.042	1434.267
Heat Loss In Joules/Mole For CO	lCO	176.2662	166.5497	209.5209	570.5246	946.6857	1175.283	2499.984
Heat Loss In Joules/Mole For N2	lN2	8136.883	2083.935	2138.851	3888.480	5226.488	4396.558	5530.541
Heat Loss In Joules/Mole For CH4	lCH4	-19393.1	8337.747	10150.26	1185.794	-2510.57	27534.34	26098.00
Heat Loss In Joules/Mole For H2O	lH2O	12516.06	4498.575	2941.880	2858.435	2505.049	-2253.28	-2657.15
Heat Losses For All Gases	tloss	2840.378	15626.51	23872.56	22612.76	23467.48	81686.82	24154.66
Energy Input	E. In	15327.99	14403.83	22606.17	40009.95	62755.36	73808.34	26250.17
Energy Output	E. Out	12487.61	-1222.68	-1266.38	17397.19	39287.87	-7878.47	2095.511

SUMMARY OF ANALYSIS

Total Energy Input (kJ)	255000
Total Energy Output (kJ)	61000
Operating Efficiency	24%
Average Combustion Air Flow (cfm)	60

APPENDIX B

AIR CHANGE RATES

Given the apparent cracks and gaps in the building envelopes, and the widespread use of make-shift wood stoves, a number of important assumptions had to be made regarding air change rates for:

a) Use of the HOTCAN Energy Simulation Program; and

b) Computation of energy savings due to installation of specific conservation measures.

Given the limited value of carrying out pressurization tests, we made estimates based on observations of dwelling envelope conditions, and on stove type (respecting the differing air requirements for different types of stoves).

ASSUMPTIONS FOR USE WITH HOTCAN

From reviewed literature, we initially estimated that air requirements for the types of stoves used and their manner of use was in the range of 50 to 75 cfm (cubic feet per minute). Depending on house size, this is the equivalent of about 0.4 to 0.7 ACH (Air Changes Per Hour). The exact air change rate will be dependent upon the stove efficiency and the temperature at which the house is kept. The flue gas analyses indicated combustion air requirements of 39 cfm using the oval stove, and 60 cfm using the horizontal 45 gallon drum stove. These air volume flow rates are the equivalent of 0.3 and 0.6 ACH. Both of the above stoves have less efficient designs than the commercially-manufactured, airtight KOZI, which is used in some houses.

For purposes of inputting air change rates to HOTCAN, we computed values as indicated in Exhibit B-1. The assumption for rates took into consideration the effects of the stove type, the temperature of the interior (assuming a steady state condition equivalent to the temperature read-

ing taken near an exterior wall), and the observed condition of the windows (including use of polyethylene sheets as draft stops), doors and remainder of the building envelope. Note that the air requirement for the stove is in addition to air leakage normally induced (stack and wind pressure) through the building envelope. On this basis, we assumed a range of 0.75 to 2.5 ACH depending on the above variables.

ASSUMPTIONS FOR RETROFIT ANALYSES

The retrofit analyses considered effects of air change in two areas:

1. Application of caulking and weatherstripping; and
2. Application of new windows.

The minimum possible airtightness following retrofit caulking and sealing was selected at 0.5 ACH. This accounts for air leakage through the envelope including walls, ceilings, floors, around doors, and between window units and the rough openings in which they are set. In addition, we assumed 0.25 ACH for air leakage and natural ventilation through the proposed lexan insulated shutter window units forming the retrofit measure relating to windows.

Therefore, the total ACH for each house if caulking and weatherstripping are applied and new windows are installed is assumed to be 0.75 ACH. This is meant to account for all ventilation, air leakage and stove operation.

EXHIBIT B-1

AIR CHANGE ESTIMATES FOR USE WITH HOTCAN

As a Function of Stove Type, Dwelling Temperature, and Condition of Windows & Doors

STOVE TYPE	ASSUMED STEADY STATE INTERIOR TEMPERATURE	
	62-67°F	68-72°F
KOZI & other air tight stoves	1/4 ACH	1/2 ACH
Other stoves	1/2 ACH	3/4 ACH

OBSERVED CONDITIONS OF WINDOWS AND DOORS	OBSERVED BUILDING ENVELOPE CONDITION	
	Good	Defective
Good	3/4 ACH*	1 ACH*
Poor	1 1/2 ACH*	1 3/4 ACH*

* in addition to ACH related to stove use.

If polyethylene is covering all of most of the windows and the polyethylene is intact, then deduct 1/4 ACH.

The above information is additive, producing an air requirement range of 3/4 - 2 1/2 ACH.

APPENDIX C

FUEL WOOD MEASUREMENTS AND APPLICATION

TWO DAY WOOD BURNING MONITORING

Wood burning monitoring was carried out over a 50 hour period and compared to hourly temperature readings for the corresponding period, obtained from the local weather station.

Measurements and calculations were as follows:

- 409 lbs. of black spruce burned over a period of 50 hours;
- black spruce has density of 25.458 lbs/ft^3 dry basis;
- this wood had a measured moisture content of 23%;
- therefore, assuming 1 ft^3 of wood

$$\frac{\text{weight of water}}{\text{weight of wood + weight of water}} = 0.23$$

$$\text{weight of wood + weight of water} = \frac{\text{weight of water}}{0.23}$$

$$25.458 = \text{weight of water} \left(\frac{1}{0.23} - 1 \right)$$

$$\text{weight of water} = \frac{25.458}{3.3478}$$

$$= 7.604 \text{ lbs.}$$

- therefore density of wood burned

$$\begin{array}{r} 25.458 \text{ lbs/ft}^3 \\ 7.604 \text{ lbs/ft}^3 \\ \hline 33.062 \text{ lbs/ft}^3 \end{array}$$

$$\frac{409 \text{ lbs.}}{33.062 \text{ lbs/ft}^3} = 12.371 \text{ ft}^3$$

at 91 ft^3 (of solid wood) per cord - this represents 0.136 cords burned in this 50 hour period.

- therefore the number of cords burned per year

$$= \frac{\text{average \# of annual Degree Days}}{\text{\# of Degree Days during this period}} \times 0.136$$

$$= \frac{7210}{83.3} \times 0.136 = 11.7 \text{ cords}$$

Temperature readings were obtained from local weather station on hourly basis corresponding to precise time period of measured wood burning. Because the occupants of this house generally keep the interior temperature about 68-70° F, this conventional degree day approach was considered adequate for extrapolation.

An alternative calculation, assuming green wood at 46% moisture content produced a yearly requirement of 16.2 cords. For retrofit analysis purposes we assumed a value equal to the average amount, i.e. 14 cords.

APPLICATION

This amount was applied as a ratio to the HOTCAN requirement for delivered year energy as compiled for the house in which the wood burning test was carried out. The resulting ratio of annual cords to the delivered energy requirement as produced by HOTCAN was used in subsequent retrofit analysis. This assumed similar stove efficiencies and homogeneous heating, both of which are not likely to occur. However, given the range of accuracy required analysis purposes, it was agreed that these assumptions would suffice.

APPENDIX D

RELATIVE HUMIDITY MEASUREMENTS

To get an indication of how temperature and moisture varies within the houses, wet and dry bulb temperature readings were taken and relative humidity levels were computed. The results are summarized in Exhibit D-1.

Within a given dwelling, the temperature varies as much as 25 Fahrenheit degrees (Dwelling G24). Relative humidity was measured as high as 60% at 70°F (Dwelling G10). In one severe case, the crawl space relative humidity was 78% (Dwelling G22).

In one house (R7, not shown in Exhibit D-1) the living room temperature was found to be 61°F at the floor and 89°F at the ceiling. This degree of temperature stratification is not surprising given that a) the predominant mode of heat transfer between the stove and surrounding is by radiation and natural convection (as opposed to forced air movement); and b) that the level of insulation in the floor is low. Although stratification readings were not carried out in other houses, similar results can be expected. Improved crawlspace insulation would reduce this temperature range.

Relative humidity levels are generally high, given that at the time of measurement outdoor temperatures were in the -20° to -16°C range. Under these conditions, any air exfiltration will result in water vapour condensing within the ceiling, wall or floor structure. This in turn could eventually lead to severe damage due to rot and reduce energy efficiency by wetting of the insulation.

EXHIBIT D-1

RELATIVE HUMIDITY MEASUREMENTS

HOUSE	LOCATION OF MEASUREMENTS	RELATIVE HUMIDITY %	DRY BULB TEMPERATURE °F	MOISTURE PROBLEMS (as observed)
G6	Kitchen Storage Room	58 72	70 61	Mould along ceiling tiles of interior corner at Storage Room. Mould along exterior corner of storage room.
G7	Kitchen Bedroom	36 40	73 72	Condensation staining on ceiling tiles.
G8	LivingRoom Bedroom Washroom	38 36 30	66 68 66	None.
G9	Bedroom Livingroom Washroom	52 41 46	70 75 73	Mould growing in exterior corner of bedroom. Condensation and frosting over entire ceiling.
G10	Storage Room Bedroom Kitchen	60 54 40	70 77 73	Condensation on attic hatch casement - always a pot of water on stove.
G11	Kitchen Corner Bedroom Storage Room	58 40 36	61 63 66	Green mould has been found at times in exterior corner of corner bedroom.
G12	Storage Room Bedroom Kitchen	42 38 34	63 68 72	Condensation on ceiling tiles.
G13	Bedroom Bedroom Kitchen	40 46 32	72 72 79	None.
G14	Storage Room Livingroom Bedroom	47 50 42	61 66 64	Condensation staining on storage room ceiling, no polyethylene in ceiling.
G15	Bedroom Livingroom Kitchen	22 24 24	66 72 72	None.
G16	Bedroom Kitchen	42 26	48 57	Frost along wall in bedroom.

EXHIBIT D-1 (Cont'd)

HOUSE	LOCATION OF MEASUREMENTS	RELATIVE HUMIDITY %	DRY BULB TEMPERATURE °F	MOISTURE PROBLEMS (as observed)
G17	Bedroom Bedroom Kitchen	34 30 38	50 61 61	Frosting on storage room ceiling and SE bedroom.
G18	Kitchen Bedroom Bedroom	38 34 33	68 70 71	Condensation on ceiling tiles in this bedroom.
G19	Bedroom Bedroom Storage Room	38 36 40	70 75 72	None.
G20	Bedroom Storage Room Bedroom	44 44 49	79 79 77	Frost stains on bedroom ceiling.
G21	Bedroom Kitchen Livingroom	44 44 44	66 67 66	None.
G22	Bedroom Storage Room Livingroom Crawlspace	40 38 32 78		Floor joists have deteriorated, condition is visible in the crawlspace.
G24	Kitchen Bedroom NE Bedroom	40 30 74	73 75 45	Ceiling in NE Bedroom drips because of condensation. Condensation noted around edges of attic hatch.
G25	Kitchen Bedroom Bedroom	30 28 28	66 70 70	None.
G26	Livingroom Bedroom Kitchen	24 26 22	70 66 77	None.
G27	Kitchen Bedroom Bedroom	26 90 36	75 57 70	Condensation on Bedroom ceiling.

EXHIBIT D-1 (Cont'd)

HOUSE	LOCATION OF MEASUREMENTS	RELATIVE HUMIDITY %	DRY BULB TEMPERATURE °F	MOISTURE PROBLEMS (as observed)
G29	Livingroom Bedroom Bedroom	48 26 30	63 68 66	None.
G30	Kitchen	38	72	None.

APPENDIX E

RETROFIT MEASURES

This section provides details of the retrofit measures suggested. These details form the basis of the retrofit measure costing provided by Island Lake Tribal Council and were used in the retrofit analyses shown in Section II of this report. Five types of retrofit measures are proposed:

- Adding attic insulation;
- Insulating crawlspaces;
- Re-skinning walls and insulating crawlspaces;
- Replacing windows;
- Caulking and weatherstripping.

These are briefly described below and illustrated following the notes.

ADDING ATTIC INSULATION

Attic insulation is provided to upgrade existing conditions to approximately R-40. If the existing condition is less than R-12, two layers of R-20 batts are added. If existing condition is R-12, one layer of R-8 batts and one layer of R-20 batts are added. If the existing level of insulation is greater than R-12, one layer of R-20 batts is added.

Styrofoam baffles or specially-treated paper baffles should be placed between joists at the eaves to ensure adequate space is provided for air movement between the underside of the roof sheathing and the insulation (see Exhibit E-1).

INSULATING THE CRAWLSPACE

To compensate for low or non-existent insulation in the floors, retrofit insulation is provided either by means of a new skirt formed by a 2 x 6 (or 2 x 4) stud wall or by insulating the outside of the grade beam. In both cases, a horizontal layer of R-20 glass fiber batts is provided inside the perimeter of the crawlspace to a width of 6'-0". Note that this measure is only appropriate if there is no evidence that the dwelling is on frost susceptible soil (if the soil immediately adjacent to the foundations or grade beam is not heated, then there is greater chance of frost heaving and subsequent building damage). If the dwelling shows evidence of frost heaving, then the method of crawlspace insulation as shown in the re-skinning retrofit measures (Exhibit E-3) should be used; but the horizontal insulation should extend 7 ft. beyond the dwelling edge. Openings in the grade beam or skirting should be provided to allow ventilation of the crawlspace in summer (see Exhibit E-2).

RE-SKINNING WALLS AND INSULATING OF CRAWLSPACES

This measure provides additional insulation on the exterior of walls and takes advantage of the construction technique to provide insulation around the perimeter of the crawlspace. This insulation is extended horizontally outward from the foundation wall. It can apply equally to those cases where a 2 x 6 stud wall can serve as structural support for skirting or where grade beams are used. However, when the dwelling shows evidence of frost heaving, the horizontal extension for the insulation should be 7 ft.

Two options are provided. One option uses expanded polystyrene for the upper portion of the wall and extruded polystyrene around the perimeter of the crawlspace, in contact with soil. The other option uses glass fiber batts to provide additional insulation to the upper walls and extruded polystyrene (Type II or better) in contact with the soil at the perimeter of the crawlspace (see Exhibit E-3).

ADDING WINDOWS

This retrofit measure takes into account widespread problems of broken glass and difficulty in getting a good seal with sliding windows. Two or three fixed layers of lexan (a highly damage-resistant clear plastic material), spaced 3/4" apart, are placed in a wood frame combined with an insulated shutter (insulated to R-10), which is placed on the inside of a screened opening. In this manner, the glazed surfaces do not move. The shutter is on a piano hinge and provides a casement-like closure (see Exhibit E-4). Windows with 2 and 3 layers of glazing were considered. Two layers of glazing are suggested because this generally provided approximately the same payback as three layers, and has the advantage of 20% lower capital cost.

CAULKING AND WEATHERSTRIPPING

This retrofit measure involves systematically applying caulking around door frames and windowframes, and around junctions of walls, floors, and ceilings. This latter area involves removal of trim and caulking prior to replacing the trim. It is extremely important to ensure that all air leakage points are sealed between the attic space and the heated living area.

Weatherstripping is applied around doors at sides and the top with sweep-type weatherstripping at the bottom of the door. For windows, weatherstripping is applied wherever required, unless the windows are being replaced (see Exhibit E-5).

A wide variety of application techniques are possible. For detailed designs, refer to Air Sealing Homes for Energy Conservation, Buildings Energy Technology Transfer Program, Energy Mines and Resources Canada, 1984.

The effect of air-tightening with respect to increased humidity will not be known until the caulking and weatherstripping is completed.

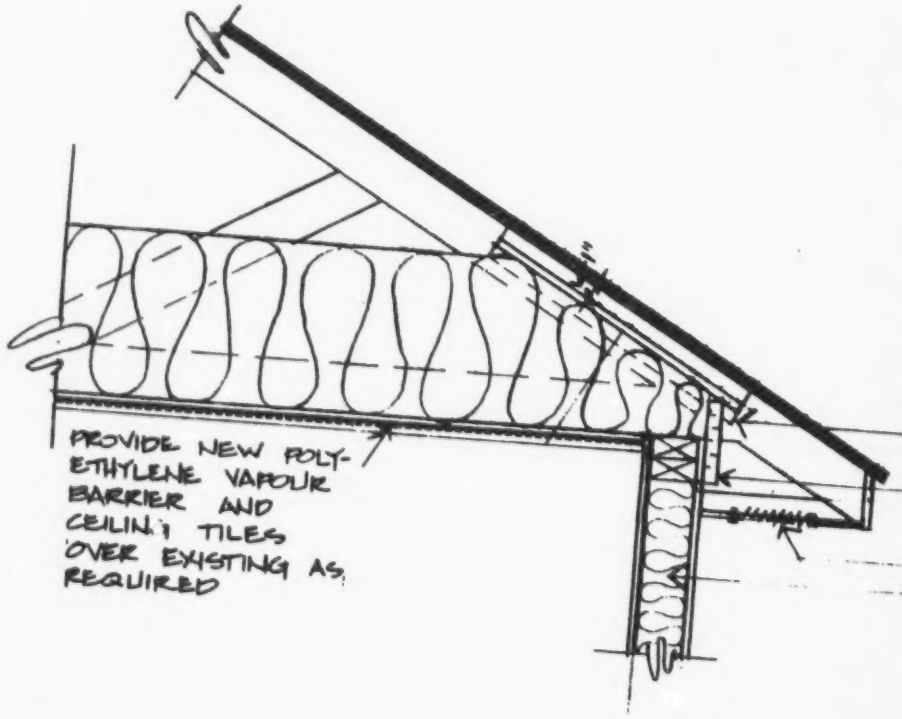
However, in anticipation of increased humidity levels and the need for additional air change to help ensure adequate air quality, the following equipment is suggested,

- an air intake pipe from the header (with the opening protected by a screen) running between the floor joists and having an inlet in the floor under or immediately near the wood stove; and
- a 4-6" stack vent in one of the bedrooms having an inlet near the floor and passing up through attic space (the portion of the pipe passing through attic space should be insulated).

In this matter, fresh air can be brought in without creating uncomfortable drafts, and there is the opportunity for exhausting stale air without the need for mechanical equipment.

EXHIBIT E-1

ATTIC UPGRADING



INSULATION UPGRADING :
UPGRADE TO ≥ R40
EXISTING-
LESS THAN R-12
ADD 2 BATTS @ R-20
R-12
ADD 1 R-8 + 1 R-20 BATT
GREATER THAN R-12
ADD 1 R-20 BATT

PROVIDE NEW POLY-ETHYLENE VAPOUR BARRIER AND CEILING TILES OVER EXISTING AS REQUIRED

EXPANDED POLYSTYRENE OR TREATED PAPER INSULATION BAFFLES

INSULATION STOP - SCRAP SHEET GOODS OR 1" BOARD INSULATION (PREFERRED)

SOFFIT VENT (ADD AS REQUIRED)

EXISTING STUD WALL

B1

EXHIBIT E-2

CRAWL SPACE INSULATION

SCALE : 1"= 1'-0"

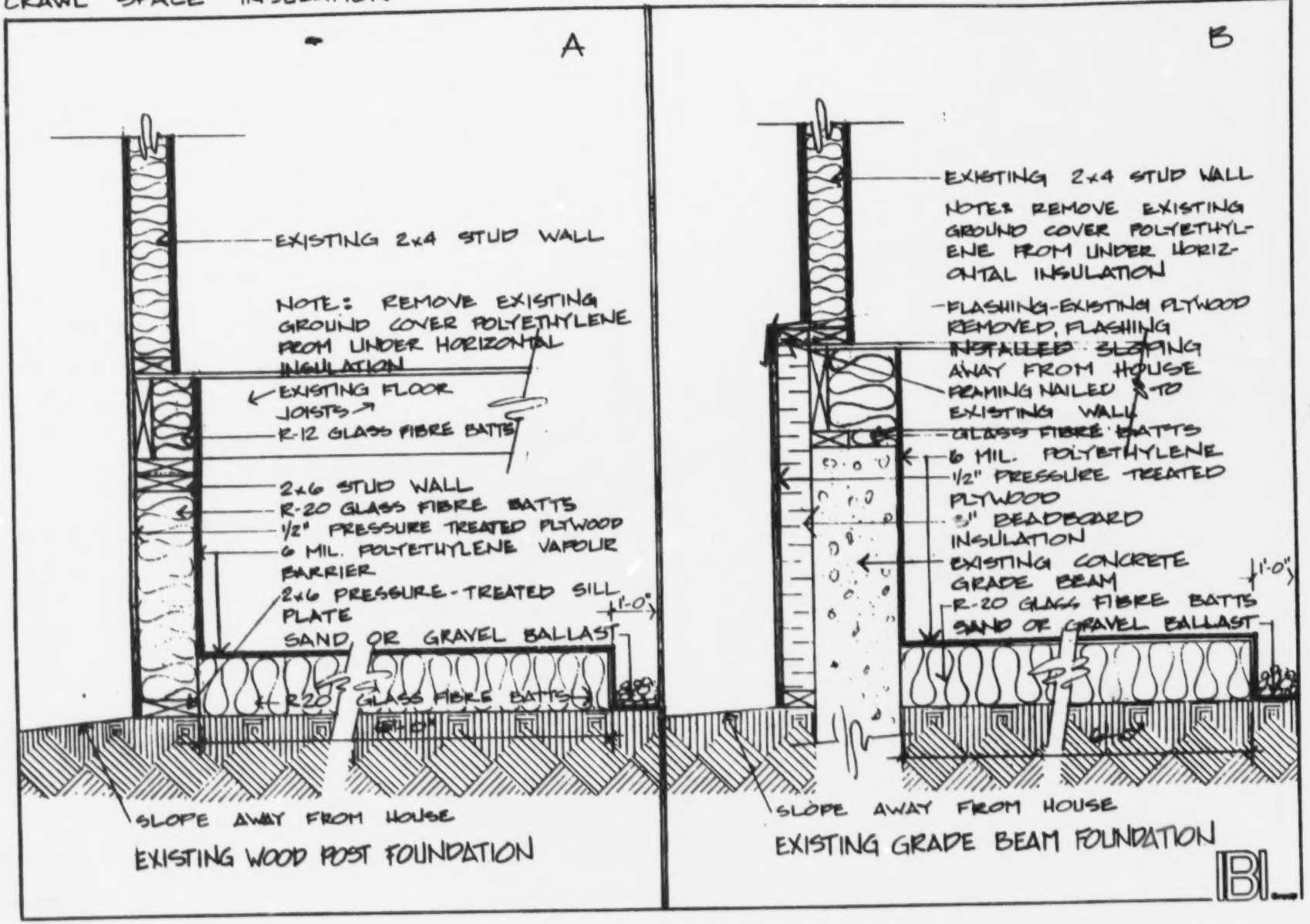

A
EXISTING 2x4 STUD WALL
NOTE: REMOVE EXISTING GROUND COVER POLYETHYLENE FROM UNDER HORIZONTAL INSULATION
EXISTING FLOOR JOISTS
R-12 GLASS FIBRE BATTS
2x6 STUD WALL
R-20 GLASS FIBRE BATTS
1/2" PRESSURE TREATED PLYWOOD
6 MIL. POLYETHYLENE VAPOUR BARRIER
2x6 PRESSURE-TREATED SILL PLATE
1'-0"
SAND OR GRAVEL BALLAST
R20 GLASS FIBRE BATTS
SLOPE AWAY FROM HOUSE
EXISTING WOOD POST FOUNDATION
B
EXISTING 2x4 STUD WALL
NOTE: REMOVE EXISTING GROUND COVER POLYETHYLENE FROM UNDER HORIZONTAL INSULATION
FLASHING-EXISTING PLYWOOD REMOVED, FLASHING INSTALLED SLOPING AWAY FROM HOUSE
FRAMING NAILED TO EXISTING WALL
GLASS FIBRE BATTS
6 MIL. POLYETHYLENE
1/2" PRESSURE TREATED PLYWOOD
3" BEADBOARD INSULATION
EXISTING CONCRETE GRADE BEAM
1'-0"
R-20 GLASS FIBRE BATTS
SAND OR GRAVEL BALLAST
SLOPE AWAY FROM HOUSE
EXISTING GRADE BEAM FOUNDATION
B1

EXHIBIT E-3

ABOVE GRADE WALLS UPGRADING

SCALE: 1" = 1'-0"

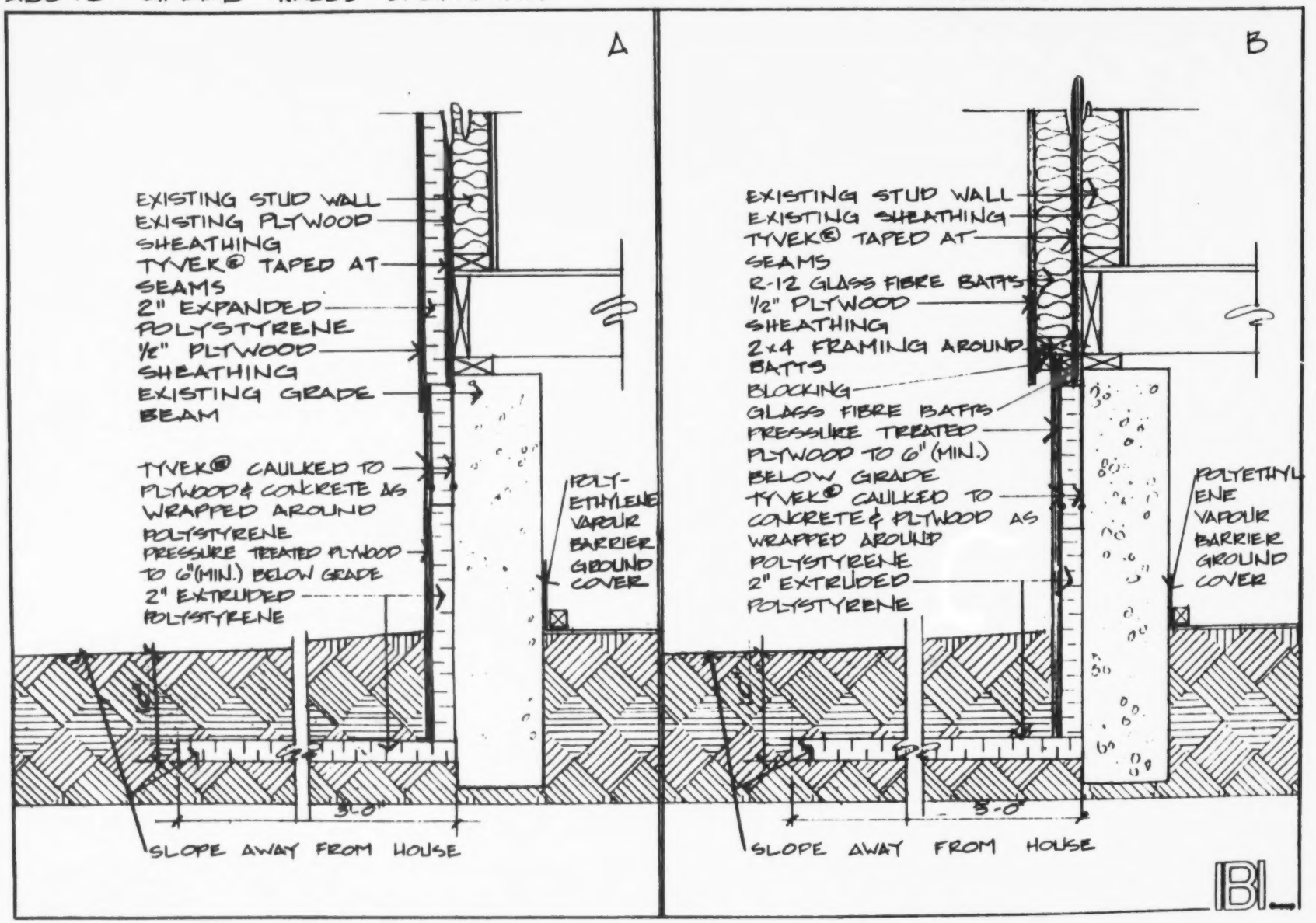
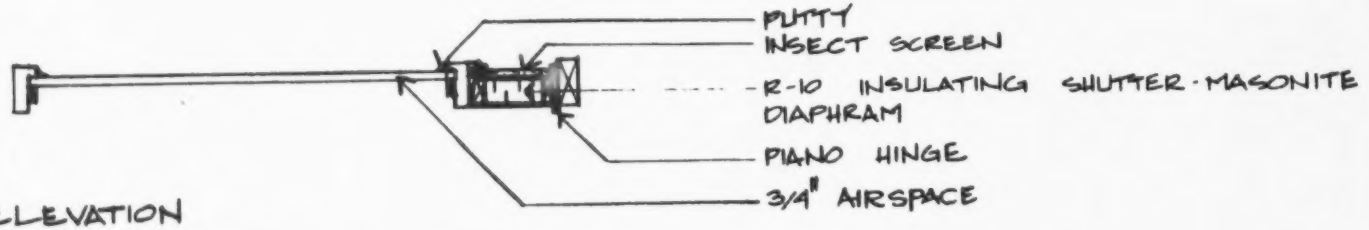
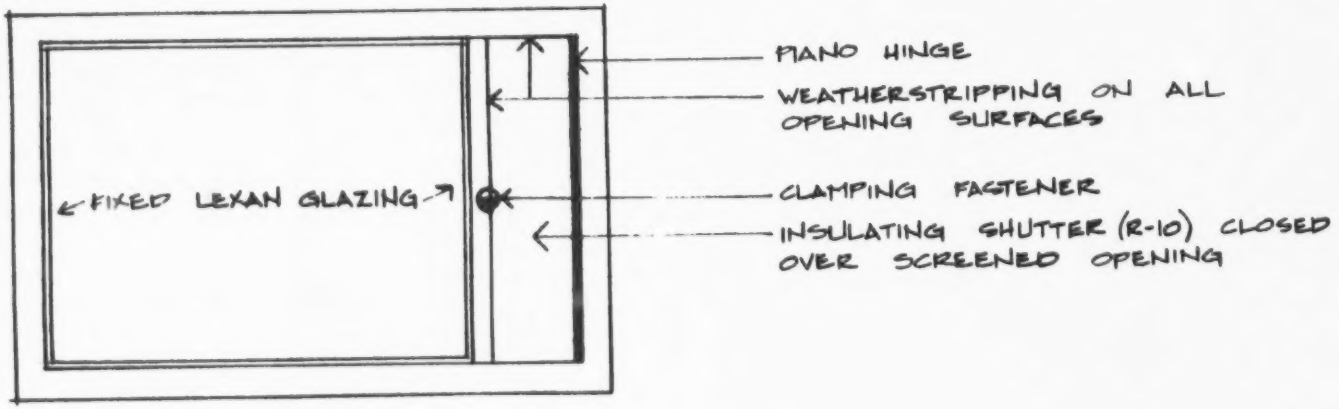


EXHIBIT E-4
REPLACEMENT WINDOWS

PLAN



INTERIOR ELEVATION



WINDOW PRICING FOR DOUBLE GLAZING FOR EACH OF THREE OVERALL WINDOW SIZES:

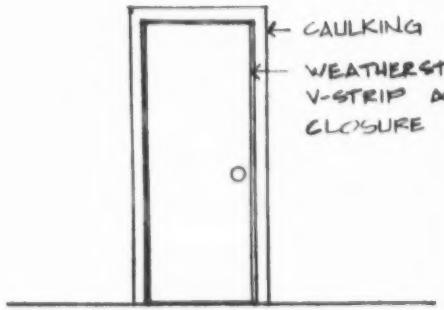
SMALL	15" x 30"	SHUTTERS
MEDIUM	24" x 48"	6"
LARGE	35" x 70"	WIDE

B1

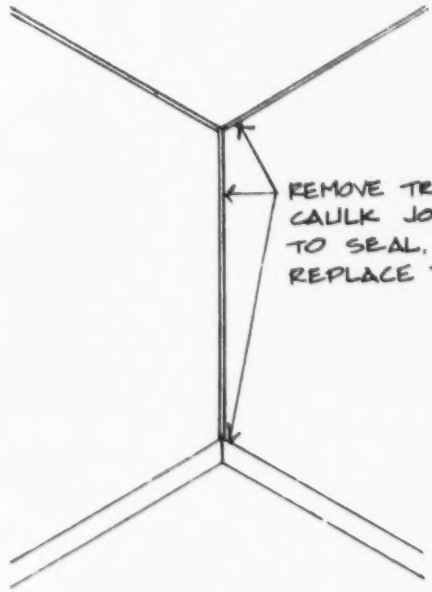
EXHIBIT E-5

CAULKING, WEATHERSTRIPPING

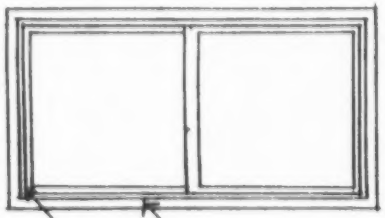
AROUND DOORS



AROUND JOINTS



AROUND WINDOWS



FOR MORE DETAILS SEE AIR SEALING HOMES FOR ENERGY CONSERVATION BUILDINGS ENERGY TECHNOLOGY TRANSFER PROGRAM, ENERGY, MINES AND RESOURCES, CANADA

APPENDIX F

RETROFIT COSTS

All retrofit costs were supplied by staff of the Island Lake Tribal Council, and were based on the retrofit options described in Appendix E. These costs are summarized in Exhibit F-1 to F-7.

Costing was carried out for each retrofit measure for two different sized bungalows representing both ends of the commonly-found size range. The dimensions of these bungalows are:

a) 24' x 32'; and

b) 24' x 38'.

From the overall costs shown in Exhibit F-1 to F-7, unit costs were developed for each bungalow size on the following basis:

- Attics; per square foot of attic area;
- Crawlspace perimeter; per lineal foot of perimeter;
- Re-skinning of wall and insulation of crawlspace perimeter; per linear foot of wall;
- Windows; by window size type (small, medium, large), adjusted for overall existing window area;
- Caulking and weatherstripping; per sq. ft. of floor area.

For each of the unit costs associated with the two different bungalow sizes, an average was taken (in all cases, except for windows, the unit cost did not differ greatly between the two bungalow sizes). For windows, costs were estimated by summing the cost by number and size type of windows and modifying this by the ratio of the measured window area to the window area represented by the number of windows in the house by size type.

EXHIBIT F-1

ATTIC INSULATION COSTS

BUNGALOW SIZE	MATERIALS	MATERIALS COST ($)	LABOUR COST ($)	FREIGHT ($)
24' x 32'	R-8	122.88	128.00	
	R-20	222.72	128.00	$20.00
	Baffles	38.50	50.00	
24' x 38'	R-8	145.92	128.00	
	R-20	264.48	128.00	$20.00
	Baffles	45.00	50.00	

Note: Dwellings are retrofitted with R-8 and/or R-20 insulation.

SOURCE: Island Lake Tribal Council.

EXHIBIT F-2

CRAWLSPACE INSULATION COSTS (SKIRT)

	MATERIAL COST	LABOUR COST
BUNGALOW 24' x 32'		
224 sq. ft. R20 Glass Fiber Insulation Crawlspace Walls	64.96	64.00
88 sq. ft. R20 Glass Fiber Insulation Ground area	25.52	64.00
56 sq. ft. R20 Glass Fiber Insulation Joist Fillers	10.64	32.00
224 LF 2 x 6 Double Top Plates	76.84	64.00
176 LF 2 x 6 Stud Walls at 16" Center	59.84	64.00
112 LF 2 x 6 Pressure Treated Sill Plate	76.16	64.00
14 sheets 1/2" 4 x 8 Pressure Treated Plywood	371.00	128.00
1,000 sq. ft. 6 mil poly	27.00	64.00
Removal of Existing Ground Cover		64.00
Total	711.96	608.00
Freight Cost		135.00
TOTAL MATERIALS, LABOUR, FREIGHT	$1,454.96	
BUNGALOW 24' x 38'		
248 sq. ft. R20 Glass Fiber Insulation Crawlspace Walls	71.98	64.00
100 sq. ft. R20 Glass Fiber Insulation Ground Area	29.00	64.00
162 sq. ft. R12 Glass Fiber Insulation Joist Fillers	11.78	23.00
248 LF 2 x 6 Double Top Plates	84.32	64.00
194 LF 2 x 6 Stud Walls 16" Center	65.96	64.00
124 LF 2 x 6 Pressure Treated Sill Plates	84.32	64.00
16 sheets 1/2" - 4 x 8 Pressure Treated Plywood	424.00	128.00
1,000 sq. ft. 6 mil poly	27.00	64.00
Removal of Existing Ground Cover		64.00
Total	798.36	608.00
Freight Cost		143.00
TOTAL MATERIALS, LABOUR, FREIGHT	$1,549.36	

SOURCE: Island Lake Tribal Council

EXHIBIT F-3

CRAWLSPACE INSULATION COSTS (GRADE BEAM)

	MATERIAL COST	LABOUR COST
BUNGALOW 24' x 32'		
120 LF flashing	90.00	32.00
14 sheets 1/2" 4 x 8 Plywood	203.00	128.00
7 sheets 1/2" 4 x 8 Pressure Treated Plywood	185.50	64.00
14 sheets 3" 4 x 8 Beadboard Insulation	237.30	128.00
112 LF 2 x 4 Spruce Plates	22.40	64.00
112 LF 2 x 4 Pressure Treated Plates	50.40	64.00
528 sq. ft. R20 Glass Fiber Insulation (Ground)	153.12	128.00
112 sq. ft. R12 Glass Fiber Insulation Joist Spaces	21.28	64.00
1,500 sq. ft. 6 mil poly	40.50	64.00
Total	1,003.50	736.00
Freight Cost		105.00
TOTAL MATERIALS, LABOUR, FREIGHT	$1,844.50	
BUNGALOW 24' x 38'		
130 LF Flashing	97.50	32.00
16 sheets 1/2" 4 x 8 Plywood	232.00	128.00
14 sheets 1/2" 4 x 8 Pressure Treated Plywood	208.00	64.00
16 sheets 3" Beadboard Insulation	271.20	128.00
124 LF 2 x 4 Spruce Plates	24.80	64.00
124 LF 2 x 4 Pressure Treated Plates	55.80	64.00
744 sq. ft. R20 Glass Fiber (Ground)	215.76	128.00
124 sq. ft. R12 Glass Fiber Joist Spaces	23.56	64.00
1,500 sq. ft. 6 mil poly	40.50	64.00
Total	1,169.12	736.00
Freight Cost		116.00
TOTAL MATERIALS, LABOUR, FREIGHT	$2,021.12	

SOURCE: Island Lake Tribal Council

EXHIBIT F-4

RE-SKINNING COSTS (POLYSTYRENE)

	MATERIAL COST	LABOUR COST
BUNGALOW 24' x 32'		
39 2" 4 x 8 Sheets Expanded Polystyrene	340.00	256.00
11 2" 4 x 8 Sheets Extruded Polystyrene Crawlspace	144.10	128.00
12 2" 4 x 8 Sheeted Extruded Polystyrene Ground	157.20	128.00
Excavating		300.00
39 Sheets 1/2" 4 x 8 Plywood	565.55	256.00
11 Sheets 1/2" 4 x 8 Pressure Treated Plywood	291.50	100.00
1,556 sq. ft. of TYVEK®	140.00	128.00
500 ft. of taping	15.00	32.00
Total	1,754.55	1,328.00
Freight Cost		138.00
TOTAL MATERIALS, LABOUR, FREIGHT	$3,220.55	
BUNGALOW 24' x 38'		
42 2" 4 x 8 Sheets Expanded Polystyrene	474.46	256.00
12 2" 4 x 8 Sheets Extruded Polystyrene Crawlspace	157.20	128.00
13 2" 4 x 8 Sheets Extruded Polystyrene Ground	170.30	128.00
Excavating		300.00
42 Sheets 1/2" 4 x 8 Plywood	609.00	256.00
12 Sheets 1/2" 4 x 8 Pressure Treated Plywood	318.00	100.00
1,720 sq. ft. of TYVEK®	140.00	128.00
600 ft. of taping	16.00	32.00
Total	1,884.96	1,328.00
Freight Cost		145.00
TOTAL MATERIALS, LABOUR, FREIGHT	$3,357.96	

SOURCE: Island Lake Tribal Council

EXHIBIT F-5

RE-SKINNING COSTS (POLYSTYRENE AND GLASS FIBER)

	MATERIAL COST	LABOUR COST
BUNGALOW 24' x 32'		
1,220 sq. ft. R12 Glass Fiber Insulation	231.80	128.00
39 Sheets 1/2" 4 x 8 Plywood	565.50	256.00
1,040 LF 2 x 4 Plates & Studs	208.00	384.00
112 LF 2 x 2 Blocking	12.32	32.00
1,556 sq. ft. of TYVEK®	140.00	128.00
11 Sheets 2" 4 x 8 Extruded Polystyrene Crawlspace	144.10	128.00
12 Sheets 2" 4 x 8 Extruded Polystyrene Ground	157.20	128.00
11 Sheets 1/2" 4 x 8 Pressure Treated Plywood	291.50	67.00
500 LF of Taping	15.00	32.00
Excavating Cost		300.00
Total	1,765.42	1,583.00
Freight Cost		230.00
TOTAL MATERIALS, LABOUR, FREIGHT	$3,578.42	
BUNGALOW 24' x 38'		
1,340 sq. ft. R12 Glass Fiber Insulation	254.60	128.00
42 Sheets 1/2" 4 x 8 Plywood	609.00	256.00
1,136 LF 2 x 4 Plates & Studs	227.20	448.00
124 LF 2 x 2 Blocking	13.64	32.00
1,720 sq. ft. of TYVEK®	140.00	128.00
12 Sheets 2" 4 x 8 Extruded Polystyrene Crawlspace	157.20	128.00
13 Sheets 2" 4 x 8 Extruded Polystyrene Ground	170.30	128.00
12 Sheets 2" 4 x 8 Pressure Treated Plywood	318.00	64.00
600 LF of Taping	16.00	32.00
Excavating Cost		300.00
Total	1,905.94	1,644.00
Freight Cost		261.00
TOTAL MATERIALS, LABOUR, FREIGHT	$3,810.94	

SOURCE: Island Lake Tribal Council

EXHIBIT F-6

LEXAN WINDOW COSTS

WINDOW SIZE	MATERIALS $	LABOUR $	TOTAL $
Small (15" x 30")	210	50	260
Medium (24" x 48")	280	60	340
Large (35" x 70")	430	70	500

NOTE: The above dimensions include the 6" wide insulated shutter. The prices are for triple glazing (each pane 0.75 inches apart). Double glazing is 20% less.

SOURCE: Island Lake Tribal Council

EXHIBIT F-7

CAULKING AND WEATHERSTRIPPING COSTS

BUNGALOW SIZE	MATERIALS	MATERIAL COST $	LABOUR COST $	TOTAL $
24' x 32'	Caulking	66	96	197
	Weatherstripping	19	16	
24' x 38'	Caulking	77	128	239
	Weatherstripping	18	16	

SOURCE: Island Lake Tribal Council

APPENDIX G

RETROFIT ANALYSES DETAILS

The details of the retrofit analyses as provided for each house in Section II, are summarized here to further the reader's understanding of the process and assumptions. Each measure is discussed separately below.

GENERAL COMMENTS

The retrofit analyses were carried out using spreadsheet software (Lotus 1-2-3). For each retrofit measure, the ratio of the R value (or air change rate) following application of the measure to the existing R value (or air change rate) is used to determine the change in annual cords of wood consumed.

No reliable estimates were available on cord consumption. The estimate of annual cord consumption is based on the relationship determined by taking the results of the fuel wood measurement extrapolated to the full heating season (see Appendix C), and relating that number to the delivered energy requirement from the HOTCAN analysis of the house in which the wood burning monitoring was carried out (although the cord requirement is the total purchased energy, and the HOTCAN estimate is for total delivered energy, the use of a ratio nullifies this incompatibility).The ratio produced by relating the two numbers is applied to the HOTCAN energy requirement for the house being analyzed for retrofit.

In general, the measures are independent of one another. The one exception is for the re-skinning options which include insulating the crawlspace perimeter. This means that if one of the re-skinning options is selected, there is no need to consider the separately-listed crawlspace insulation measure.

Input information common to all houses is shown in Exhibit G-1. An example of house-specific input information is shown in Exhibit G-2.

INPUT COMMON TO ALL RUNS — EXHIBIT G-1

BELOW GRADE HEAT LOSS FACTOR - CRAWLSPACE			0.35
R VALUE OF ABOVE GRADE CRAWLSPACE INSULATION -OPTION A			20
R VALUE OF ABOVE GRADE CRAWLSPACE INSULATION -OPTION B			12
ADDED R VALUE OF WALL -OPTION A			10
R VALUE OF ABOVE GRADE CRAWLSPACE INSULATION			10
BELOW GRADE HEAT LOSS FACTOR -OPTION A			0.35
ADDED R VALUE OF WALL -OPTION B			12
R VALUE OF ABOVE GRADE CRAWLSPACE INSULATION			10
BELOW GRADE HEAT LOSS FACTOR -OPTION B			0.35
AVERAGE R VALUE OF NEW WINDOW ASSEMBLY			2.8
ACH ATTRIBUTED TO NEW WINDOW ASSEMBLIES			0.25
AREA OF REFERENCE WINDOWS	-Small	(sq ft)	3.125
	-Medium	(sq ft)	8.000
	-Large	(sq ft)	17.014
MIN ACH ACHIEVABLE BY CAULKING AND WEATHERSTRIPPING			0.75
BASE SEASONAL CORDAGE EXTRAPOLATED FROM 2-DAY MONITOR			14

UNIT COSTS

ATTIC,ADD R8	-Variable	($/sq ft)	$0.21
ATTIC,ADD R20	-Variable	($/sq ft)	$0.34
ATTIC	-Fixed		$198.00
CRAWLSPACE A	-Variable	($/linear ft.)	$7.58
	-Fixed		$608.00
CRAWLSPACE B	-Variable	($/linear ft.)	$10.13
	-Fixed		$736.00
RESKINNING A	-Variable	($/linear ft.)	$16.63
	-Fixed		$1,328.00
RESKINNING B	-Variable	($/linear ft.)	$17.67
	-Fixed		$1,614.00
REF. WINDOWS	-Small	(per unit)	$208.00
	-Medium	(per unit)	$272.00
	-Large	(per unit)	$400.00
CAULKING AND WEATHER STRIPPING		($/linear ft.)	$2.69
PRICE OF FUEL WOOD		($/CORD)	$105.00

EXHIBIT G-2
SAMPLE INPUT DATA (G-22)

ISLAND LAKE SPREADSHEET ANALYSIS - INPUT DATA

TOTAL ACH INPUTTED INTO HOTCAN	1.25
PERCENT SEASONAL LOSS OF AIR CHANGE	23
OLD R VALUE OF CEILINGS	12
OLD R VALUE OF FLOOR	3
COMBINED PERCENT SEASONAL HEAT LOSS	57
NUMBER OF LAYERS OF R8 TO BE ADDED TO ATTIC	1
NUMBER OF LAYERS OF R20 TO BE ADDED TO ATTIC	1
OLD R VALUE OF WALL	12
PERCENTAGE HEAT LOSS THROUGH WALLS	12

WINDOWS	AREA	OLD R VALUE	% SEASONAL LOSS
SOUTH	16	2.51	1.3
NORTH	10	2.51	0.81
EAST	11.1	2.51	0.9
WEST	25	2.16	2.36
S-EAST		4000	0
S-WEST		500	0

HOTCAN ANNUAL SPACE HEATING (GJ)	122
WIDTH OF HOUSE (IF RECTANGULAR)	24
LENGTH OF HOUSE (IF RECTANGULAR)	28
%AREA OF HOUSE	672
%PERIMETER OF HOUSE	104
PIERS AND POSTS -(ENTER 1) OR GRADE BEAM -(ENTER 2)	2
AVERAGE HEIGHT OF FLOOR ABOVE GRADE (ft)	2
NUMBER OF SMALL WINDOWS	1
NUMBER OF MEDIUM WINDOWS	4
NUMBER OF LARGE WINDOWS	1
ACH ATTRIBUTABLE TO OLD WINDOW ASSEMBLIES	0.5

ADD TO CEILING INSULATION

Insulation is added to the attic until total level of insulation of approximately R-40 is reached. Therefore, different houses will have different amounts of insulation added. This in turn provides varying energy savings, installation costs and paybacks.

INSULATE CRAWLSPACE

Results for crawlspaces were computed corresponding to foundation type:

- piers and footings or post and pads: Option A
- Grade Beam: Option B

New R values calculated are shown as an equivalent R value; i.e. heat loss coefficients are calculated for the proposed insulated crawlspace wall or insulated grade beam and partially insulated ground. These heat loss coefficients are summed and expressed as the approximately equivalent total level of insulation that would have to be placed between the floor joists to achieve the combined thermal resistance provided by the existing insulation plus the crawlspace retrofit insulation (either A or B, see Exhibit E-3). Because different sized houses will have different areas of crawlspace wall and ground areas underneath the floor through which heat loss occurs, the total "equivalent" R value added by this measure will vary from house to house. Note that even if there is no floor insulation, a minimum of R-3 is assumed to account for present performance.

RE-SKIN OUTSIDE WALL - OPTION A AND OPTION B

These measures reduce heat loss through the walls and floors by adding insulation to the walls and crawlspace perimeter. This is achieved by adding an additional layer of polystyrene insulation (Option A) or glass fiber batts (Option B) to the wall from the outside, and for both cases by

constructing and insulating a crawlspace wall or insulating the existing grade beam from the outside. Since two distinct areas of heat loss are involved in this measure, one of which is dealt with by the 2nd measure (Insulate Crawlspace, discussed above) it was felt that the values of percentage of total fuel consumed at present, existing R value, new R value, and fuel saved (columns 3, 4, 5 and 6 on the retrofit analysis tables) should be kept separate for each heat loss component area. Column 7 then provides the total fuel saved for the entire measure; that is, the sum of the savings shown for each component in Column 6. Within either Option A or Option B, the same level of insulation is added (R-10 for Option A, R-12 for Option B) to the existing wall regardless of whether it is presently insulated to R-12 or R-20.

REPLACE WINDOWS

In general, there are two kinds of heat loss associated with windows: conductive losses (glass itself has very little thermal resistance) and air leakage losses (either cold outside air being blown in or warm indoor air being sucked out through gaps between the window panes and the surrounding frame or between panes designed to slide past one another).

Since both components of loss were taken into account in the design of the lexan retrofit window unit, it was felt that the reduction achieved in each type of loss should be indicated. Therefore, similar to the Re-skinning Measures, the values of percentage of total fuel consumed at present, existing R value (or existing air changes per hour), new R value (or new air changes per hour) and fuel saved (columns 3, 4, 5 and 6) are shown for each component of heat loss. Column 7 then shows the total fuel savings for this measure, which is the sum of the two values shown in column 6.

In order to obtain a representative R value for the existing windows, a weighted average based on window area for all the windows was calculated. For the proposed lexan unit, obtaining a representative R

value was a slightly more complex procedure. Because the new unit will have an insulated shutter built into it which will have the same width regardless of the overall window dimensions, an R value representative of all the windows of all houses had to be arrived at, regardless of the dimensions of the individual windows in individual houses (the alternative approach was to compute R values for each house on a window by window basis). As a compromise, an average R value weighted on the basis of window area and representative of all the windows was calculated for eight houses evenly distributed among the four communities. The R values so obtained were very close together and averaged out to be approximately R-4.2 for triple glazing and 2.8 for double glazing. These average R values were therefore assumed to be representative of all of the windows of all of the houses. Computer runs were done for both. Generally it was found that double glazing has a slightly shorter payback, with 20% lower retrofit costs. In a few cases triple glazing was analyzed to have a significantly lower payback, but since the paybacks were generally well over 60 years, double glazing has been shown through the analysis.

While we would normally expect this value to be higher than the R value of the existing windows, there are some houses in which this is not the case. In most of these cases, polyethylene film which has been temporarily put in place over double glazed windows has been considered for energy loss purposes to be equivalent to an additional layer of glazing. Triple glazed units have been installed in a very few of the houses. Since in general, the insulating panel within the proposed double glazed lexan units has not been able to raise the equivalent R value of the unit to that of a triple glazed unit, the R value of the new unit is shown to be lower than the weighted average of the "triple glazed" existing units. Where the difference is substantial, a negative value is obtained in the fuel saved by component column (column 6) for the conductive losses.

The second component of window losses, air change, has already been discussed briefly at the beginning of this section. In recognition of the fact that perfectly airtight seals for the shutter are impossible to achieve, and that some ventilation will be required, a minimum air leakage

of 0.25 air changes per hour has been assumed. In reality, this figure will vary from house to house depending upon how often the occupants open up the moveable panel to allow fresh air to enter, and how careful they are to prevent it from freezing open.

The value for existing air changes per hour (Column 4) was estimated on the basis of the type of window unit (loose fitting vs tight fitting or sealed units) and on any obvious cracks or gaps through which air air leakage could occur, as well as the presence or absence of polyethylene installed over the window.

The R value of the existing and proposed windows is based on an assumed 3/4" gap between layers of glazing. In reality the existing glazing spacing is sometimes less than this amount. Also, although the existing polyethylene window covers are assumed to act as an additional glazing layer, the resulting R value is probably overstated, thereby producing a longer payback for the retrofit windows.

CAULK AND WEATHERSTRIP

As discussed in Appendix B, the air leakage losses occurring through the building structure and around the doors was estimated on the basis of the general condition of the structure, the extent to which doors were tight or loose fitting, the type of wood stove, and the temperature at which the house was maintained at the time of the audit. These last two points are of importance as discussed below.

Type of Stove

Combustion and draft control requirements vary depending upon the type of stove required.

The flue gas tests for the two types of stoves tested (oval, horizontal 45 gallon drum) provided an average value of 50 cfm for the steady state air volume flow rate. For a small size house (24 x 32) with a

heated volume of approximately 6,100 ft.^{3} this is equivalent to about 0.5 ACH.

Flue gas testing was not done on the third type of stove used, the KOZI. It can be estimated that its air requirement would be lower because it is designed to be used in an air-tight manner. A value of 10-20 cfm is a reasonable estimate for the combustion and draft control air requirements of an air-tight stove operated in an air-tight manner. This translates into an air leakage rate of 0.1 - 0.2 ACH.

Temperature At Which House Is Maintained

The higher the temperature at which a house is maintained, the greater the rate at which wood must be burned, which in turn increases the combustion air requirement. Therefore, as shown in Exhibit B-1, for houses where the temperature was assumed to be maintained above 67°F, extra ventilation of 0.25 ACH was assumed.

From the experience that professional air sealing companies have had in retrofit air tightening, it has been found that achieving a total air change rate of less than 0.5 ACH is extremely difficult. We therefore chose this value as the minimum possible airtightness level achievable through caulking and weatherstripping. This value refers only to air leakage through the walls, floors, ceilings, around doors, and between window units and the rough opening into which they are set. It does not include the minimum total air leakage and natural ventilation value of 0.25 ACH assumed for the proposed lexan window units.

Adequacy of Air Change

The minimum ACH for a retrofitted house is 0.75 ACH, more than enough for stove requirements. However, any significant reduction in air change may lead to moisture problems (other surface condensation or conden-

sation within the structure). Demonstration projects should be carefully monitored for any signs of increased humidity.

USE OF ELECTRICITY

If the electrical grid is extended to provide service greater than 15 amps, the kWh rate will be the same as that for service in southern rural Manitoba. This rate is currently just under 3¢ per kWh. At this rate, paybacks can be expected to be about 8-10% longer than if fuel wood at $105/cord is used. This assumes that the pre-retrofit houses would have electric baseboard heaters to provide homogenous interior temperatures in the range of 68-71°F.